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**EAST BAY HILLS FIRESTORM  
RESPONSE ASSESSMENT  
PHASE I FINAL REPORT**

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Prepared For The:

**EAST BAY MUNICIPAL UTILITY DISTRICT**

By:

VSP Associates, Inc.  
455 University Avenue, Suite 340  
Sacramento, CA 95825

G & E Engineering Systems, Inc.  
5011 Crystalridge Court  
Oakland, CA 94605

Barbara Foster Associates  
Liberty Dock #14  
Sausalito, CA 94965

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## EXECUTIVE SUMMARY

The purpose of assessment is to address two basic questions about District's preparation for and response to the October 1991 East Bay Hills firestorm emergency:

1. How well prepared was the District to respond to this emergency?
2. How well did the District respond to the emergency?

Answering each of these questions has two main components, both of which are addressed in this report: water system performance and emergency management evaluation.

Chapters 1 and 2 of this report provide an overview of the scope of this assessment and briefly review the firestorm and its impact on the District's water system. Chapter 3 reviews the District's water distribution system and its performance during the firestorm emergency. Chapter 4 reviews the District's emergency planning and emergency response.

The background findings summarized below provide information helpful in understanding the more technical information presented in answering the questions posed in this assessment. These background findings are based primarily on the assessments conducted for this report, but some findings are based on other published reports about the firestorm.

## BACKGROUND FINDINGS

- The October 20, 1991 East Bay Hills firestorm spread extremely rapidly due to a combination of factors including the weather conditions (high winds, extremely low humidity, and high temperatures) and the high vegetative fuel loads in the fire area.
- Water supplies were one of several important factors in fire suppression efforts. Other important factors included weather, topography, fuel loads, and fire suppression resources (firefighting personnel, apparatus, equipment, and strategy).
- In the East Bay Hills firestorm, fire suppression efforts were hampered by the steep topography and narrow streets, by communications difficulties among the hundreds of companies fighting the fire, and by water supply limitations in some areas.
- There are five elements of design which, in combination, largely determine how well a water distribution system can respond to fire emergencies: fire flows, storage, pumping plants, pipe sizes, and hydrant spacing. Of these, fire flows (the water flow rate and duration) are the best single indicator of fire suppression capability.





- Fire flows available at any location depend principally on water storage in reservoirs, pipe diameters in the system, and on other water demands being made simultaneously.
- Modern and historical fire flow guidelines principally indicate water flows to be available for suppression of single structure fires, from a single hydrant or several nearby hydrants. Neither modern nor historical fire flow standards were intended to provide fire flows sufficient to suppress numerous fires simultaneously.

## **QUESTIONS**

### **1. How well prepared was the District to respond to this emergency?**

#### **A) Water System Performance**

- The District's water distribution system was built over many years. Older portions of the system were built using design criteria which differ from modern design criteria. Therefore, maximum available fire flows vary from one part of the system to another.
- The District's water distribution system in the firestorm area was generally well-prepared for the fires for which it was designed:
  - 1) Reservoirs supplying each of the 11 pressure zones involved in the fire were filled to a high percentage of capacity before the firestorm and all contained water well in excess of the fire-fighting reserves necessary to meet either current or historical fire flow standards.
  - 2) Pumping plants were fully operational before the firestorm and all had been designed with sufficient capacity to maintain specified fire fighting water reserves under conditions of maximum daily normal water usage.
  - 3) Distribution pipe sizes in most areas were consistent with providing fire flows at or above current and historical standards.
  - 4) Hydrant spacings in the burn area were consistent with common design practices set by fire departments.





- In some pre-1930 portions of the District's distribution system, pipe diameters are too small to deliver high fire flows. Therefore, in these areas the District's water distribution system was less well-prepared than in more modern portions of the system.
- The District's water distribution system in the East Bay Hills firestorm area was not designed to supply fire flow rates and durations commensurate with fire suppression efforts for an event of the magnitude of the October 20, 1991 firestorm.
- The District's preparedness for fire suppression (fire flow design standards and fire flow capabilities) was generally comparable to that of other local water agencies. The District's water storage (relative to daily demand) was two to four times higher, while pumping plant capacities were lower than at other local water agencies.

#### **B) Emergency Management Evaluation**

- The District and its staff were generally well prepared to deal with emergencies. However, the District's emergency planning was primarily operations-based and thus did not address the full range of emergency management issues.

### **2. How well did the District respond to the emergency?**

#### **A) Water System Performance**

- Overall, the water system performed well during the emergency. Where fire-suppression demands so required, each of the 11 pressure zones in the fire area provided at least the fire flows currently required by the Oakland and Berkeley Fire Departments. In two pressure zones, effective suppression of the fire was accomplished with fire flows well below the capabilities of these zones. Nine of the pressure zones provided total fire flows well in excess of current fire flow requirements.
- The availability and efficacy of water for fire suppression during the firestorm emergency varied substantially, depending on the time and location. In some areas, where other important factors were relatively favorable, moderate to very high fire flows sufficed to halt the spreading firestorm. In other areas, where other important factors were less favorable, very high fire flows (well above current standards) were insufficient to halt the spreading firestorm.
- The firestorm was an extreme "beyond design basis" event for the water system. Water demand in some areas at some times exceeded the systems' capacity to supply it. Extreme water demands were primarily a result of firefighting efforts and water losses from broken services in the fire area.





- Water supply limitations did occur in some areas at some times during the firestorm. These limitations occurred for three principal reasons:
  - 1) Sustained, extreme water demand due to fire suppression efforts and losses from flowing service connections at burned structures,
  - 2) Overdrafting by firefighters simultaneously drafting from many hydrants in a single pressure zone, and
  - 3) Distribution system limitations [small pipe diameters in older (mostly pre-1930) portions of the system].
- Fire flow limitations impeded fire suppression efforts in some areas at some times during the firestorm, particularly in the Broadway Terrace and Dingee Pressure Zones.
- Power failures at pumping plants did not have a substantial effect on water availability during the peak water demand period of the firestorm. If the power failures had not occurred or if immediate emergency power had been available, the additional water supplies which would have been available in pressure zones where limitations occurred during peak demand times would have been less than ten percent of peak water usages.
- After-action reports from firefighters stated that many hydrants had limited or no fire flows available. In many cases, this occurred even when the pressure zone supplying the hydrant had plenty of water. This apparently paradoxical phenomenon is attributed to "overdrafting," in which firefighters attempted to draft water simultaneously from many hydrants in a pressure zone. Under these circumstances, hydrants near the water source for the zone may have had strong flows, while hydrants further from the source had progressively lower flows. The water distribution system cannot simultaneously provide fire flows from multiple hydrants which are each equal to the maximum possible flow from a single hydrant.

#### **B) Emergency Management Evaluation**

- The District's emergency response was generally effective during the firestorm. What needed to be done during the emergency was accomplished by District personnel effectively and in a timely manner. From the beginning of the event, District staff took numerous actions to utilize the District's full capabilities in support of fire suppression efforts. For example:
  - 1) District field crews were in the fire area checking the status of reservoirs and pumping





plants, opening zone gates, shutting off broken services, and providing communications links and other requested resources to fire fighting personnel,

2) District rangers worked extremely long shifts in stopping the firestorms' spread in the Grizzly Peak area, and supported firefighters efforts by driving water trucks into the fire area.

3) District staff drove fuel trucks into the fire area to resupply fire apparatus.

4) District crews moved emergency equipment (including generators and pumps) where needed in the fire area, as soon as fire conditions permitted.

## **CONCLUSIONS AND RECOMMENDATIONS**

- The District should consider upgrading older portions of its water distribution system to current fire flow standards. Upgrade priorities should consider fire risks and the existing fire flow capabilities of the older portions of the system.
- The District should consider modification/augmentation of current fire flow standards in high risk areas to provide greater fire flows for major conflagrations. However, other fire hazard mitigation activities may be more effective and more cost-effective in reducing future fire losses.
- The District should encourage fire hazard mitigation actions, including vegetation control and fire-safe construction practices in high fire risk areas.
- The District should consider enhancing pumping plant capabilities and its ability to transfer water between zones via interconnections and pressure regulators.
- The District's emergency response could be improved by undertaking more comprehensive emergency management planning and by conducting more training exercises.





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## 1.0 INTRODUCTION

### 1.1 SCOPE OF THIS ASSESSMENT

The purpose of this assessment is to answer, based on the best available information, two basic questions about the District's response to the October 20, 1991 East Bay Hills firestorm:

1. How well prepared was the District to respond to this emergency?
2. How well did the District respond to the emergency?

Each of these questions has two main components: water system performance and emergency management, both of which are addressed in this report. This Phase I report is a retrospective examination of how well prepared the District was to respond to this emergency and how well the District actually performed in response to this specific emergency event. The report contains a detailed assessment of the District's preparation before the firestorm and of its response during the firestorm emergency. The report includes recommendations for improvements which are based on the conclusions drawn from this assessment.

More detailed recommendations will be presented in the Phase II report. The Phase II work tasks are prospective (looking to the future) to address two main subjects:

1. What changes, including the consideration of alternatives, should be made to the water system and related operational policies, practices and design criteria which will enhance the District's ability to respond to an emergency similar to the October 20, 1991 firestorm?
2. What changes are needed to the District's emergency plans and procedures, equipment, emergency operating center, emergency management organization, and response training and exercising to obtain a reasonable level of preparedness for the next emergency?

The Phase II report, which will be completed by November, will contain specific recommendations for possible improvements in the District's water distribution system and in its emergency management programs.

### 1.2 OVERVIEW OF THE REPORT

Chapter 2 provides a brief overview of the firestorm event and its impact on the District's water distribution system. Much of this chapter is based on the Preliminary Report on EBMUD's Response to the East Bay Hills Firestorm.<sup>1</sup> The purpose of this chapter is to provide the background and context information which is necessary to understand the more detailed technical analyses presented in Chapter 3 and Chapter 4.





Chapter 3 addresses the preparedness and performance of the District's water distribution system (reservoirs, pumping plants, distribution piping, and related facilities) during the firestorm. This chapter reviews the District's water distribution system infrastructure (both system-wide and in the fire area). The design criteria, guidelines, standards, and common practices used in the design of the District's system are reviewed and compared to practices in other water agencies, to guidelines developed by the fire insurance industry, and to current fire flow standards for new construction in Oakland and Berkeley. The immediate pre-fire status of the system is reviewed, with particular emphasis on water storage. This chapter also contains a detailed analysis of the performance of the water distribution system during the firestorm emergency, including a review of how the system itself was impacted by the fire. Estimates of the quantities of water used for fire suppression in each of the pressure zones in the firestorm area are given. This chapter ends with several conclusions and recommendations that will be among the foci of Phase II.

Chapter 4 addresses the question of how well the District was prepared for and responded to the firestorm from an emergency management perspective. The preparedness assessment includes the status of pre-event emergency planning processes and activities, the nature of existing emergency operations plans, the extent of the District's emergency response training activities, the existence of any mutual aid or other intergovernmental agreements, and several other related subjects. The response assessment includes alert and warning, District notifications, the activation and deactivation of the Emergency Operating Center, communications, situation assessment and reporting, coordination with other agencies, and similar topics. This chapter also closes with a list of conclusions and recommendations.

We have attempted to obtain as much detailed information about the firestorm as possible, using all sources of which we are aware. However, data are always incomplete in a major emergency, because during the emergency the paramount concerns are the protection of lives and property. Thus, data collection is a secondary priorities (or ignored all together). Inevitably, some data are incomplete and/or uncertain. For example, the loss of power meant that some Operations Network (OP/NET) readings from some facilities in the fire zone are not available and thus extrapolations or other sources of data or estimates had to be used. It is not possible to measure exactly how much water was being used where, for what purposes and for how long during the fire because of the combined demands from fire suppression, homeowners' attempts to protect their properties, broken service connections, and other uses. Written documentation and interview information are often incomplete. Much important information is anecdotal and may be based on indirect inferences. Nevertheless, we believe that with regard both to the water system's performance and to the District's response to the firestorm emergency, the best data available have been gathered and analyzed.

#### Chapter 1 Endnote

1. East Bay Municipal Utility District, Preliminary Report on EBMUD's Response to the East Bay Hills Firestorm, March 24, 1992.







## 2.0 OVERVIEW OF THE FIRESTORM EMERGENCY

This Chapter contains an overview of the firestorm emergency, including a review of the fire itself and background/context information about the water system during the fire to assist the reader in understanding the more detailed technical assessments presented in Chapters 3 and 4.

The Oakland Fire Department's After-Action Report<sup>1</sup> contains basic definitions which are important in understanding the severity of this emergency. A "conflagration" is defined as a fire which exceeds the boundaries of a city block of origin. A "firestorm" is a fire which creates its own weather and pulls air into the fire area, in essence, a fire feeding itself. A "fire-front" moves away from the wind direction, as the wind pushes the fire in a forward movement.

The After-Action Report noted that the October 1991 fire exhibited all three of these conditions. "The ideal weather conditions of hot dry and high velocity winds, coupled with dry and overgrown terrain, and hot temperatures triggered a conflagration which quickly turned into a firestorm with several fire-fronts... Nothing could change the conditions which made the fire expand: weather and the environment were fixed criteria in the situation." "The wind caused the fire to pre-heat everything in its path, which then caused structures and contents to explode from the radiated heat almost instantly."

### 2.1 OVERVIEW OF THE FIRE

The East Bay Hills firestorm of October 20-21, 1991 was the most destructive fire in the United States since the 1906 San Francisco earthquake fire. On October 22, 1991, President Bush made a Federal disaster declaration which recognized the severity of the firestorm disaster. This disaster has been the subject of three major reviews by panels convened by federal, state, and local officials. These reports, by the Federal Emergency Management Agency<sup>2</sup> the California Office of Emergency Services<sup>3</sup>, and the Oakland-Berkeley Task Force on Emergency Preparedness & Community Restoration<sup>4</sup>, provide overviews of the fire hazard in the East Bay Hills, report on fire suppression activities during the fire, and make recommendations for possible fire hazard mitigation actions.

The fire began Saturday, October 19, 1991, north of the Caldecott Tunnel near the eastern end of Buckingham Boulevard. This three-acre fire was controlled Saturday. Firefighters, who had doused the burn area with water before leaving the fire scene Saturday evening, returned Sunday morning to continue mop-up operations. Weather conditions changed dramatically overnight: by the morning of the 20th, a combination of high temperatures, very low humidity, and a strong, hot, dry, Foehn or Diablo wind from the northeast produced extreme fire hazard conditions. Firefighters in the Saturday burn area were dealing successfully with a few minor flare-ups when, at about 10:45 am, gusting winds blew the fire back to life. Within a few minutes, the fire was out of control and spreading very rapidly. The fire's explosive initial spreading is shown in the following map (Figure 2-1) prepared by the California Office of Emergency Services.





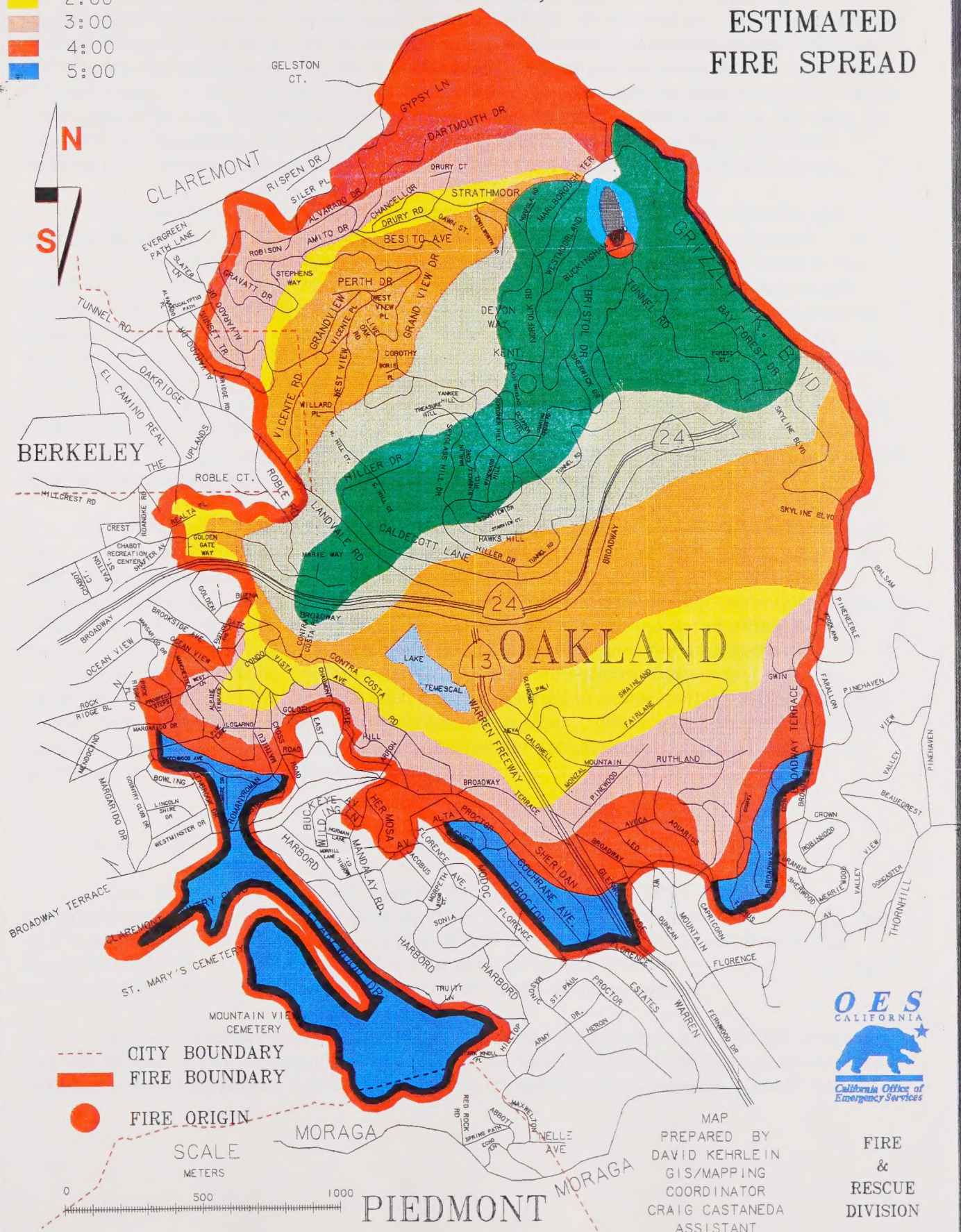


# OAKLAND/BERKELEY HILLS

Figure 2-1

## FIRE OF OCTOBER 20, 1991

ESTIMATED  
FIRE SPREAD







By 11:15 the full perimeter of the previous day's burn area was involved and the fire had ignited the shake roofs of nearby houses. The fire raced up canyon slopes towards Grizzly Peak Boulevard and was simultaneously pushed downslope along Buckingham Boulevard by the increasing winds. Within 15 minutes (by 11:30 am), the fire had advanced more than a mile southward into the Claremont area and crossed Highway 24 into the Rockridge area. Within the first hour, 790 structures were ignited (one every 4.5 seconds!). In the first ten hours that the fire roared through the East Bay Hills, homes were destroyed at a rate of one every 11 seconds. At most of these homes, the size, intensity and spreading rate of the firestorm precluded any effective fire suppression actions from being conducted either by fire department personnel or by homeowners.

The intensity of this massive firestorm completely overwhelmed the initial fire suppression efforts. If each request for additional fire suppression resources were numbered sequentially as an alarm, the East Bay Hills firestorm would have been a 27-alarm incident. If the number of alarms were determined by the number of responses equivalent to the first alarm assignment of equipment and personnel, then it would have been a 107-alarm event. The firefighters from local departments were supported by mutual aid support from 240 other fire agencies. More than 370 fire units and over 1000 firefighters fought the fire. The conflagration was not contained (no active fire head burning) until 5:45 Monday evening, after winds had subsided, and not officially declared under control until 8:00 am, Wednesday, October 23rd. The firestorm killed 25 people, injured 150, and burned over 1600 acres. It destroyed 3354 single family houses and 456 apartments, and resulted in about \$1.5 billion in damages.

The firestorm's wind-driven explosive spread was fueled by a high vegetative fuel load as well as by the structures in the area. Fire suppression efforts were hampered by high winds and extremely dry, hot (92°) weather conditions, as well as by the steep topography and narrow streets. Fire suppression was also impeded by communications difficulties among the vast numbers of mutual aid participants and by incompatibilities between Oakland hydrants and hose sizes used by non-Oakland fire departments. Difficulties experienced by the Oakland Fire Department incident command center in communicating with units involved with the fire resulted in many instances of firefighters making individual-site fire suppression strategy decisions. The firefighters performed admirably, and often heroically, under the extremely dangerous and difficult conditions generated by the East Bay Hills firestorm.

## **2.2 FIRE HAZARDS AND MITIGATION**

There are many interrelated reasons for the October 20, 1991 firestorm's devastating spread, including extreme weather conditions, high vegetative fuel loads, lack of fire-safe construction practices, rugged terrain with limited access, and limited fire suppression resources. Mitigation of fire hazards to reduce the threat of future disasters requires cooperative, coordinated actions by all of the involved parties.

Many developed areas in California, and many areas within the District (including, but not limited to the 25 miles of ridgelines in the East Bay hills), are intrinsically high to extreme fire hazard areas. The Federal Emergency Management Agency (FEMA) Hazard





Mitigation Report<sup>2</sup> noted that: "It is no longer a question of if a conflagration will occur in these areas, it's a question of where, when, and how great the losses will be." The FEMA Report emphasized that fire prevention and fire suppression are not solely the responsibility of public agencies: "Fire protection is a partnership between property owners, residents and fire protection agencies." Therefore, significant reduction of fire hazards in the Oakland-Berkeley hills and elsewhere in the District must involve cooperative coordination between all of the parties, including the District, owners, residents, fire protection agencies, and other related governmental agencies.

### **2.3 OVERVIEW OF THE WATER SYSTEM DURING THE FIRE**

Assessing emergency response actions (by fire departments and by the District) and assessing the performance of the water system during the firestorm raise an underlying fundamental issue. What are realistic, achievable expectations about fire suppression capabilities (including water supplies) during a major firestorm? A major policy question is to what extent emergency response organizations and systems (including water systems) can or should be designed, built and staffed for truly exceptional emergencies (wildland firestorms, great earthquakes) vs. the extent to which such organizations and systems should be configured for moderate to extreme emergencies?

Supporting fire suppression efforts by providing specified reserves of water is an important priority for the District. Water supplies are one of several critical parameters in fire suppression efforts. Other critical parameters include the availability of fire fighting resources (firefighting personnel, apparatus, equipment, and communications), as well as natural conditions (vegetative fuel loading, topography and weather conditions).

Technical fire flow standards used by the District, by fire departments, and by fire insurance companies are reviewed in Chapter 3. It is important to emphasize that these fire flow standards are primarily designed to provide fire suppression water to fight single structure fires, from one or more nearby hydrants. In single structure fires, homeowners expect that an emergency call will result in a prompt response from the fire department with sufficient personnel, equipment and water supplies to extinguish the fire quickly and save the house. Fortunately, in single-structure fires, such expectations are generally realized.

In a firestorm of a magnitude such as that of October 20, 1991, however, neither fire departments nor water districts have sufficient resources of personnel, equipment or water supplies to simultaneously fight hundreds of structure fires at the same level as if there were only a single structure fire. In a major disaster, the difference between the "organizational norms," what fire departments and water districts expect to and can provide, may differ substantially from the public's expectations which emerge during and after the disaster.

Schneider<sup>5</sup> has reviewed gaps in expectations between organizations and the public in natural disasters; her conclusions appear to be directly relevant to assessing responses to the firestorm. She describes a "milling process" by which people affected by a disaster search for understanding and meaning amidst the post-disaster feelings of loss,





helplessness, and alienation. An important mechanism by which emergent norms of expectations are generated by this milling process is "keynoting," in which some specific ideas are selected and focused on, while others are eliminated. "Keynoting" certain issues definitely occurred after the firestorm, for example the "error" made by the fire department in leaving the scene of the Saturday fire or the "delay" in calling for aerial support.

"Keynoting" has also occurred on important District issues, including the role of power failures at pumping plants in causing some reservoirs to empty and the inference that the water system must have been deficient when some hydrants ran dry during the firestorm. Essential goals for the District's continuing public education program are to inform the public as clearly as possible about what really happened in the firestorm and to define and disseminate realistic expectations about fire suppression capabilities (including water supplies). For example, as discussed in Chapter 3, power failures at pumping plants certainly did have negative impacts on the water distribution system. However, because the pumping plants have relatively low pumping rates, the amount of extra water which could have been provided quickly (if no power failures had occurred or if immediate back-up power had been available) is rather small (less than ten percent of peak water demand). Furthermore, all pressure zones had water during the critical times when fire fronts were burning through the zones. Therefore, despite the "keynoting" on this issue, an objective analysis indicates that the power failures at pumping plants were not a substantial factor limiting fire suppression efforts.

Likewise, the "keynoted" inference that the water distribution system must be deficient if some hydrants ran dry is not supported by objective analysis. Chapter 3 contains a detailed technical review of fire flow standards. The current standard for residential areas is generally to provide a fire flow of 1500 gallons per minute for two hours in the high risk hill areas. Where fire suppression efforts required it, every pressure zone within the burn area provided water flows well above this criterion. Nevertheless, some hydrants did provide limited or no water flows at times during the firestorm. Understanding this apparent paradox requires understanding of inherent flow limitations in water systems, particularly during an extreme situation like the firestorm emergency.

Fire flow design standards (for example, 1500 gallons per minute for two hours) are indicative of total flows obtainable from one (or several nearby) hydrants to fight a single structure fire. If, however, as happened during the firestorm, many hydrants in a pressure zone are opened simultaneously, then the water system cannot deliver 1,000 or 1,500 gpm to all of these hydrants at the same time. The flows available from any given hydrant depend not only on water pressure, pipe diameter, and pipe condition, but also on what other water demands are simultaneously being made on the system within the pressure zone. If too many hydrants are opened simultaneously, then hydrants too far "downstream" from the source of water will have little or no water flow. This was precisely what happened in some areas during the firestorm.

We reviewed numerous fire department after-action reports to help us understand where and when water supply problems occurred. Clearly, there were water supply problems at specific locations and times. The after-action reports contain references to water supply problems, but these data are not complete enough to allow them to be used for quantitative, analytical model of the systems' performance. The knowledge that water





was limited at one location is useful, but without information regarding when, where, and how much water was being drafted elsewhere in a pressure zone such anecdotal information cannot be used quantitatively. Quite understandably, given the extreme fire conditions, such detailed information is not generally available.

However, from the information available it can be inferred that there were many instances of overdrafting of water due to simultaneous drafting from more hydrants in a given pressure zone than the system's designed capacity could handle. Resulting water flow limitations were exacerbated by increasing water losses from broken services at burned out structures. Thus, within any pressure zone at any given time, hydrants near the source may have had continuously high fire flows, while hydrants further away may have had limited or no flows.

## Chapter 2 Endnotes

1. The Oakland Tunnel Fire October 20, 1991. A Comprehensive Report Prepared by the Oakland Fire Department. February, 1992.
2. Hazard Mitigation Report for the East Bay Fire in the Oakland-Berkeley Hills, in Response to the October 22, 1991 Federal Disaster Declaration Covering Alameda County, California, FEMA-919-DR-CA.
3. The East Bay Hills Fire, A Multi-Agency Review of the October 1991 Fire in the Oakland/Berkeley Hills, California Office of Emergency Services, February 27, 1992.
4. Final Report, Oakland-Berkeley Task Force, February 3, 1992.
5. S.K. Schneider, Governmental Response to Disaster: The Conflict Between Bureaucratic Procedures and Emergent Norms, Public Administration Review, Volume 52, Number 2, March/April 1992.





## **3.0 WATER SYSTEM PERFORMANCE**

### **3.1 INTRODUCTION AND FINDINGS**

This chapter covers the physical plant of the water distribution system, including the reservoirs, pumping plants, distribution piping and related hardware. The focus of this chapter is to answer, with respect to the water distribution system, the two questions posed in this assessment:

**1. How well prepared was the District to respond to this emergency?**

**2. How well did the District respond to the emergency?**

The first question (How well prepared was the District's water distribution system?) is addressed in three sections of this chapter.

Section 3.2 provides an introductory description of the physical infrastructure of the water distribution system. How the water system works is described, both system-wide and locally in the firestorm area.

Section 3.3 reviews design criteria, guidelines, standards, and common practices used in the design of the District's water distribution system. This District's design criteria are compared to common practices in other water agencies and to guidelines used in the fire insurance industry. Particular emphasis is placed on fire fighting reserves and fire flow guidelines.

Section 3.4 analyzes the status and preparedness of the District's water distribution system immediately before the firestorm on October 20, 1991. Reservoir water storage levels and other aspects of the operational status are reviewed and compared to fire flow guidelines.

The second question (How well did the District's water distribution system respond?) is addressed in two sections.

Section 3.5 describes how the water distribution system responded during the firestorm. Based on the best available data, the quantities of water provided for fire fighting in each of the 11 pressure zones which were fully or partially within the firestorm area are estimated. Based on either historical or modern fire flow guidelines, the District's water distribution system met fire flow guidelines in each of the 11 pressure zones involved in the fire. Water supply limitations which did occur in some areas at some times were due principally to excess demand (above design criteria) due to overdrafting from multiple hydrants within a pressure zone and leakage from broken service connections.

Section 3.6 summarizes water system performance during the firestorm emergency and includes conclusions and recommendations.





## FINDINGS

- The District's water distribution system was built over many years. Older portions of the system were built using design criteria which differ from modern design criteria. Therefore, maximum available fire flows vary from one part of the system to another.
- The District's water distribution system in the firestorm area was generally well-prepared for the fires for which it was designed:
  - 1) Reservoirs supplying each of the 11 pressure zones involved in the fire contained water well in excess of the fire-fighting reserves necessary to meet either current or historical fire flow standards.
  - 2) Pumping plants had sufficient capacity to maintain specified fire fighting water reserves under conditions of maximum daily water use for normal consumption.
  - 3) Distribution pipe sizes in most areas were consistent with providing fire flows at or above current and historical standards.
  - 4) Hydrant spacings in the burn area were consistent with common design practices.
- In some pre-1930 portions of the District's distribution system, pipe diameters are too small to deliver very high fire flows. Therefore, in these areas the District's water distribution system was less well-prepared than in more modern portions of the system.
- The District's water distribution system in the East Bay Hills firestorm area was not designed to supply fire flow rates and durations commensurate with fire suppression efforts for an event of the magnitude of the October 20, 1991 firestorm. Substantial upgrades in reservoir capacity, pumping plant capacity, system redundancies and distribution piping would be needed to provide fire flows for firestorms of this magnitude.
- The District's preparedness for fire suppression (fire flow design standards and fire flow capabilities) was generally comparable to that of other local water agencies. The District's water storage (relative to daily demand) was two to four times higher, while pumping plant capacities were lower than at other local water agencies.
- Overall, the water system performed well during the emergency. Where fire-suppression demands so required, each of the 11 pressure zones in the fire area provided at least the fire flows currently required by





the Oakland and Berkeley Fire Departments. Nine of the pressure zones provided total fire flows well in excess of current fire flow requirements.

- The availability and efficacy of water for fire suppression during the firestorm emergency varied substantially, depending on the time and location. In some areas, where other important factors were relatively favorable, moderate to very high fire flows sufficed to halt the spreading firestorm. In other areas, where other important factors were less favorable, very high fire flows (well above current standards) were insufficient to halt the spreading firestorm.
- The firestorm was an extreme "beyond design basis" event for the water system. Water demand in some areas at some times exceeded the systems' capacity to supply it. Extreme water demands were primarily a result of firefighting efforts and water losses from broken services in the fire area.
- Water supply limitations did occur in some areas at some times during the firestorm. Extreme water demand resulted in ten reservoirs being temporarily empty. Fire flow limitations impeded fire suppression efforts in some areas at some times during the firestorm, particularly in the Broadway Terrace and Dingee Pressure Zones.
- Power failures at pumping plants did not have a substantial effect on water availability during the peak water demand period of the firestorm. If the power failures had not occurred or if immediate emergency power had been available, the additional water supplies which would have been available in pressure zones where limitations occurred during peak demand times would have been less than ten percent.
- After-action reports from firefighters indicated that some hydrants had limited or no fire flows available, even though the pressure zone supplying the hydrant had plenty of water. This apparently paradoxical phenomenon is attributed to "overdrafting," in which firefighters attempted to draft water simultaneously from many hydrants in a pressure zone. Under these circumstances, hydrants near the water source for the zone may have had strong flows, while hydrants further from the source had progressively lower flows. The water distribution system cannot simultaneously provide fire flows from multiple hydrants which are each equal to the maximum possible flow from a single hydrant.





## **3.2 PHYSICAL INFRASTRUCTURE OF THE WATER DISTRIBUTION SYSTEM**

In this section, we first describe how the District's water distribution system works, and then, we describe the local water distribution system in the firestorm area.

### **3.2.1 System-Wide Characteristics**

The East May Municipal Utility District (the "District") was organized in 1923 under the Municipal Utility District Act of 1921. In 1928, the District acquired the properties of the East Bay Water Company, a corporation formed by an earlier consolidation of fifteen smaller companies, the oldest of which was incorporated in 1865.<sup>1</sup>

Today, the District's water distribution system (the "system") serves about 1.2 million customers. The service area covers areas both east and west of the Oakland-Berkeley hills. The system consists of approximately:

- 175 potable water reservoirs,
- 139 pumping plants,
- 6 treatment plants,
- 3,400 miles of distribution pipe, and
- over 24,000 fire hydrants.

The source for most of the District's water is the Mokelumne River watershed, a 575 square-mile area in the Sierra Nevada. This "raw" water is transported in three ninety-mile long aqueducts to the District's service area, where it is processed at one of several treatment plants. The treatment plants may also process raw water from one of several nearby terminal reservoirs (San Pablo, Upper San Leandro, and Briones). Water leaving the treatment plants is potable water which is used for residential, commercial and industrial consumption, as well as for fire fighting purposes.

Potable water is distributed in the system through about 3,400 miles of distribution pipes. Generally, this potable water is stored in one of the 175 local distribution storage reservoirs, until such time that customers use the water. About 60% of the District's customers receive this water through a gravity system, meaning that water leaves the treatment plant, and flows to the customer relying solely upon gravity to move the water. The remaining 40% of the District's customers receive water through a pumped system, meaning that the water needs to be pumped to a higher elevation to serve the customer. The system is divided into 125 pressure zones, most of which are pumped zones. In the Oakland-Berkeley firestorm area, all areas above an elevation of about 325 feet above sea level are pumped zones.

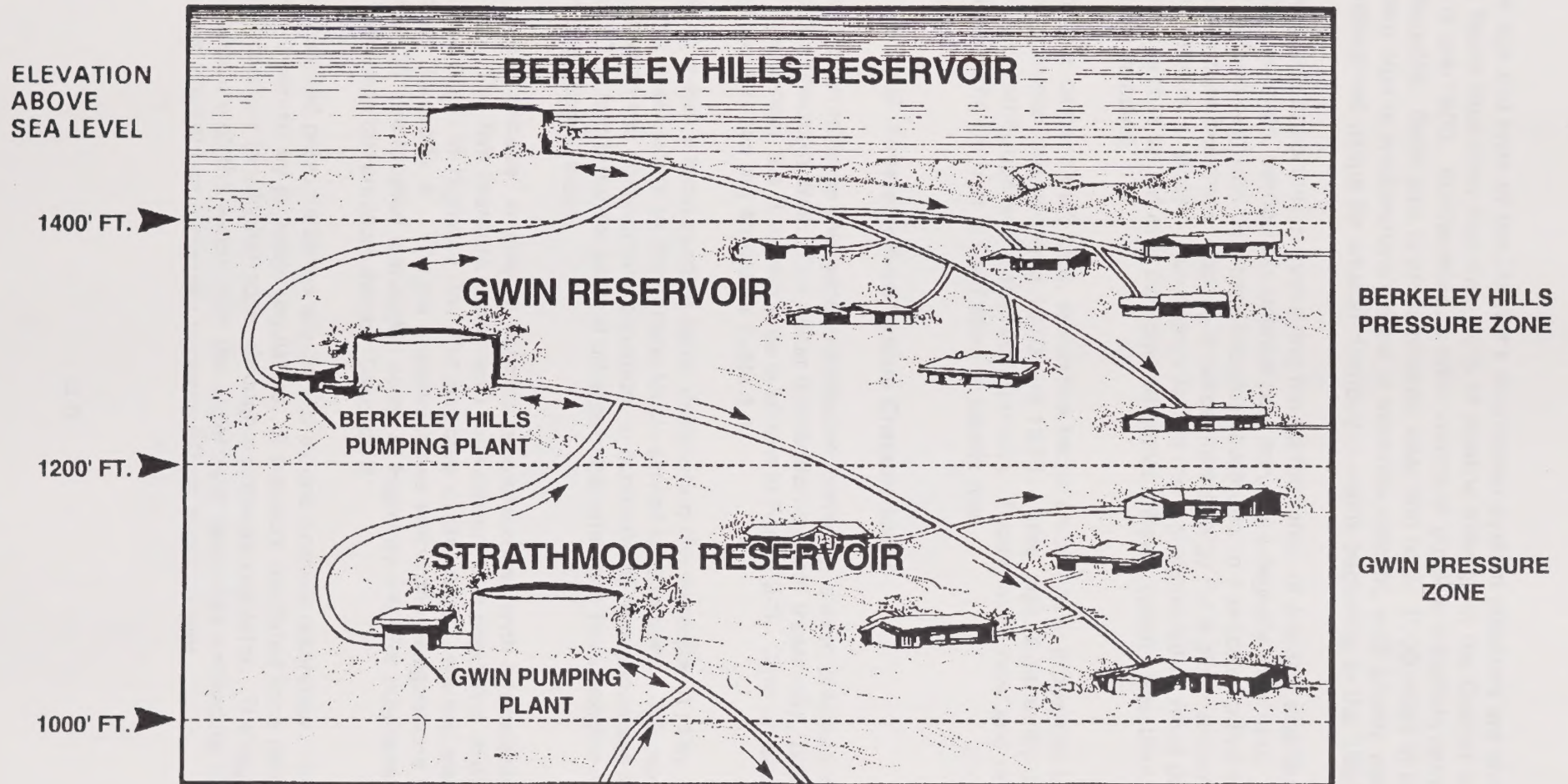
Generally, a pressure zone is supplied by one or more pumping plants. This pumping plant pumps water up to a reservoir located about 100 feet above the service area of the pressure zone. Customers within the pressure zone receive water from taps off the distribution pipes which originate from the reservoir. Figure 3-1 shows a conceptual layout of three pressure zones within the firestorm area (note that the Berkeley Hills Pressure Zone actually has only one residential service).





Figure 3-1

# PRESSURE ZONE SERVICE ELEVATIONS







The age and type of the District's distribution system pipelines are shown in Figure 3-2. This figure illustrates that over 40% of pipeline mileage in the District is pre-1950 and some is pre-1900. Furthermore, a wide variety of pipeline materials have been used over the decades. Early pipe is predominantly cast iron (over 1000 miles in the system). More modern pipe is predominantly steel or asbestos cement, with plastic pipe beginning to have widespread usage for smaller distribution mains beginning in the 1980s.

Pipe age is important in evaluating the performance of a water distribution system. Certain pipe materials, particularly unlined cast iron, may degrade over time. The inside surface of unlined cast iron pipe may become rough due to a process called tuberculation. As the pipe surface becomes rougher, it takes more energy for a given amount of water to travel past a particular point. This energy loss is more pronounced in small diameter pipe. The net result is that an old cast iron pipe will have a flow capacity less than that when it was originally installed.

Asbestos cement (AC) pipe, which has better smoothness properties than does cast iron, was in common use between 1950 and 1985. Steel pipe is generally used for the larger diameter distribution and transmission mains. Today, most new and replacement pipe installed by the District is lined steel or plastic pipe.

### **3.2.2 Firestorm Area System Characteristics**

This section reviews the water distribution system in eleven pressure zones in or adjacent to the firestorm area. The water distribution system (reservoirs, pumping plants, regulators) in and near the firestorm area is shown in Figure 3-3. Data on each of the 11 fire-area pressure zones are shown in Table 3-1.

Each zone has a letter-number-letter designation (for example, A11A). The first letter (A in this case) refers to the general locale served by this zone. The number (11 in this case) refers to the approximate elevation, in hundreds of feet above sea level, served by this zone. The last letter (or letters) differentiates one zone from another at similar elevation in one general locale.

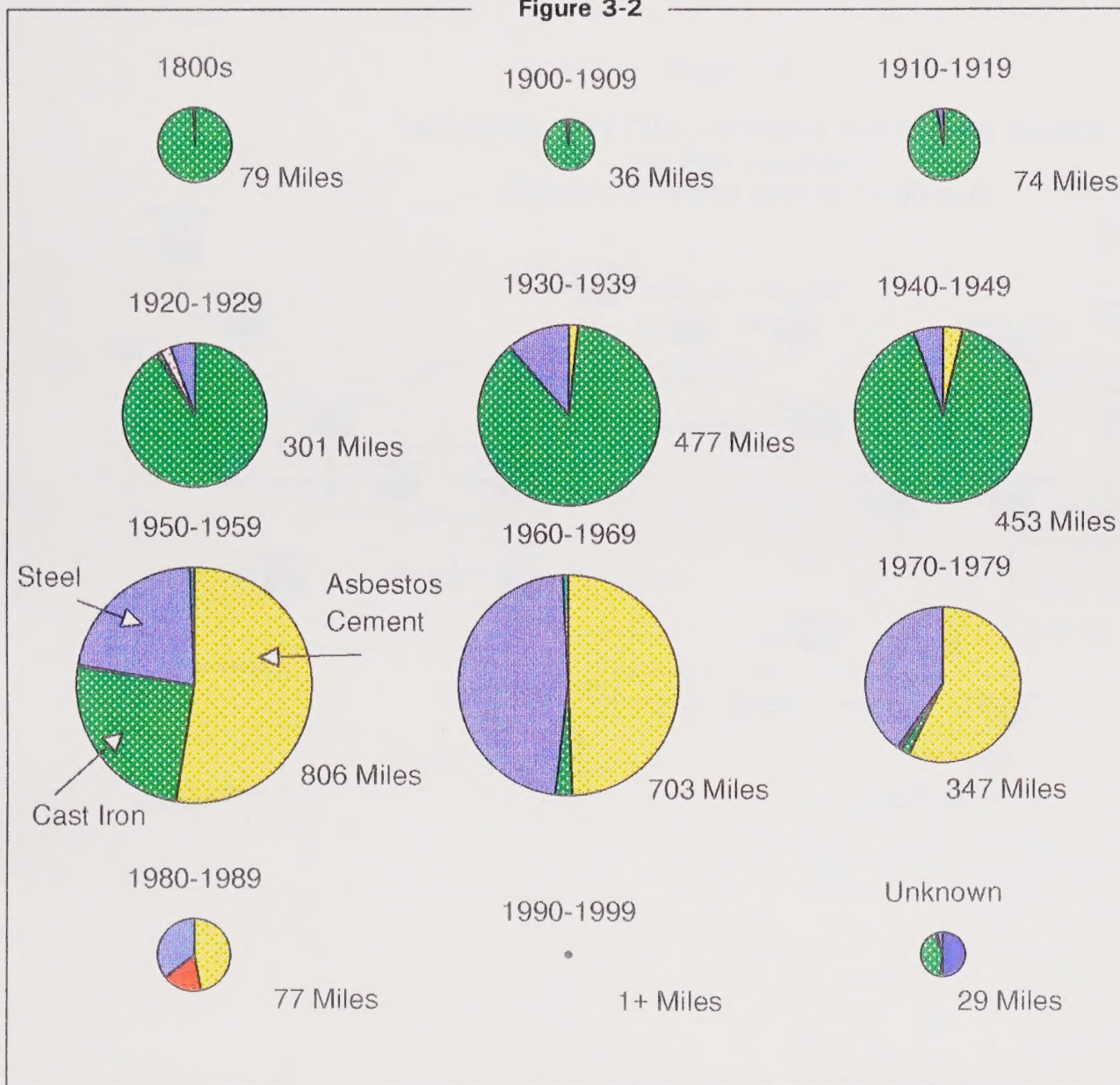
The term "cascade" is used to describe pressure zones with interrelated operating characteristics. The five pressure zones with zone designation beginning with the letter "A" are located north of Highway 24. For purposes of this report, we call these five pressure zones "Cascade A". The six pressure zones with zone designations beginning with the letter "B" are located (generally) south of Highway 24. For purposes of this report, we call these six pressure zones "Cascade B".

Most pumped pressure zones are served by one or more reservoirs. However, some zones are served by pressure regulators. A pressure regulated zone receives its water from a reservoir in a higher zone, through a pressure regulator. The regulator reduces the pressure of the water from the upper zone (generally exceeding 130 psi) down to pressures for normal use (generally between 60 psi and 120 psi).





Figure 3-2



TOTAL EBMUD  
WATER  
DISTRIBUTION  
SYSTEM

TOTAL, ALL TYPES  
3383 MILES



MILEAGES SHOWN NEXT TO PIES ARE TOTAL, ALL TYPES, BY DECADE

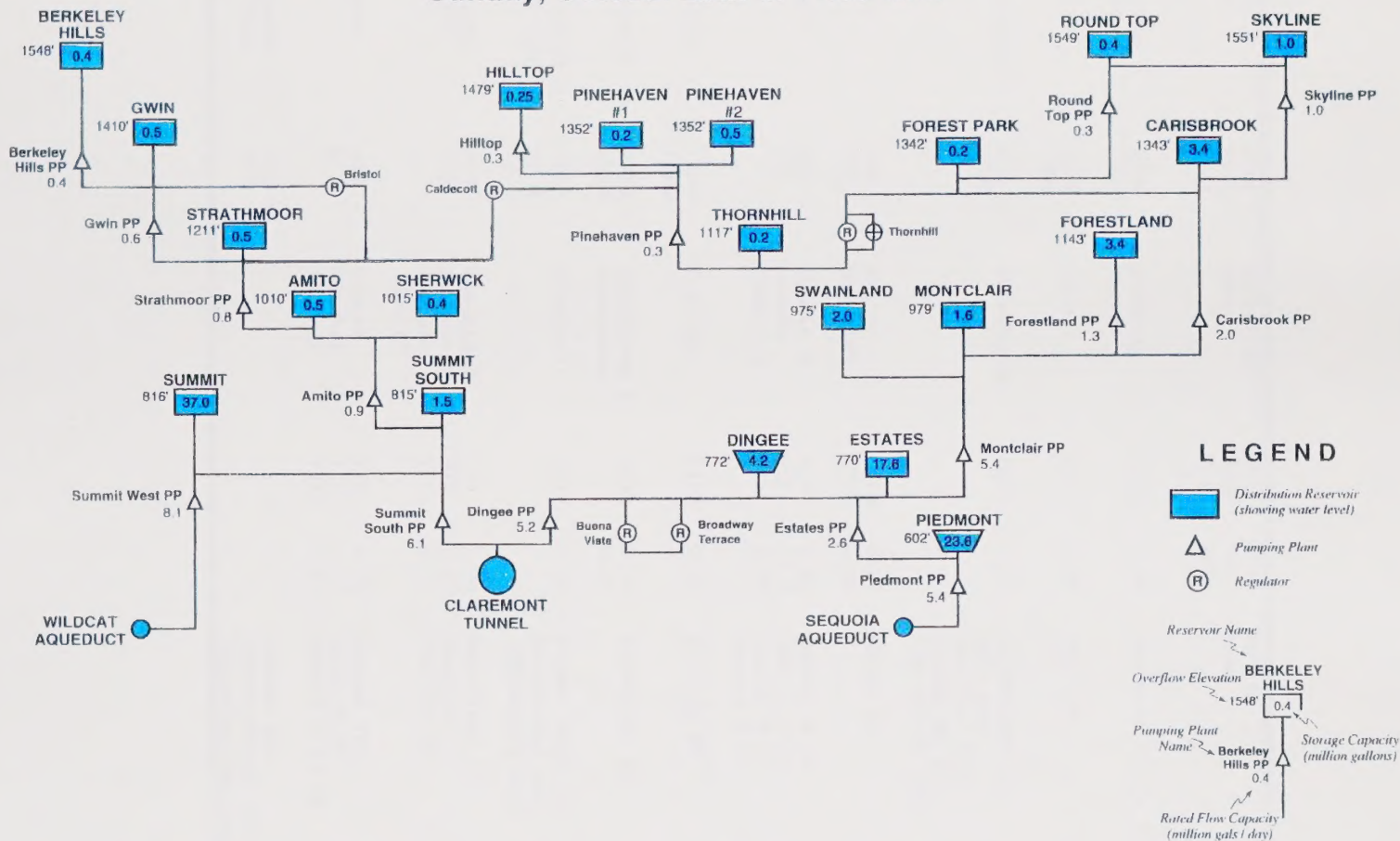
Note: Data based upon EBMUD B Maps; data excludes recently posted data, and map elements lacking database linkage. Results may differ from data from other sources.





Figure 3-3

1991 EAST BAY FIRE • EBMUD PRESSURE ZONES  
Pre-Fire Condition  
Sunday, October 20th at 11:00 a.m.







**Table 3-1**  
**Pressure Zones in the Firestorm Area**

| Zone Designation | Zone Name              | Zone Range (Ft) | Reservoir Name                           | Over-flow Elev (Ft) | Stor Cap. (MG)       | Source Name                                                                    | Source Zone                     |
|------------------|------------------------|-----------------|------------------------------------------|---------------------|----------------------|--------------------------------------------------------------------------------|---------------------------------|
| A13B             | Berkeley Hills         | 1300 - 1450     | Berkeley Hills                           | 1548                | 0.40                 | Berkeley Hills PP                                                              | A11A                            |
| A11A             | Gwin                   | 1100 - 1300     | Gwin                                     | 1410                | 0.50                 | Gwin PP                                                                        | A9B                             |
| A9B              | Strathmoor             | 900 - 1100      | Strathmoor                               | 1211                | 0.50                 | Strathmoor PP<br>Gwin Res<br>(Bristol Reg)<br>Pinehaven Res<br>(Caldecott Reg) | A7B<br>A11A<br>B9A              |
| A7B              | Amito                  | 700 - 900       | Amito<br>Sherwick                        | 1010<br>1015        | 0.49<br>0.40         | Amito PP                                                                       | A5A                             |
| A5A              | Summit                 | 500 - 700       | Summit N<br>Summit<br>Summit S           | 810<br>816<br>815   | 1.50<br>37.0<br>1.50 | Summit N PP<br>Summit W PP<br>Summit E PP<br>Summit S PP                       | A2A<br>G1A & G0A<br>A2A<br>G1Aa |
| B13Aa            | Hilltop                | 1250 - 1375     | Hilltop                                  | 1479                | 0.25                 | Hilltop PP                                                                     | B11A                            |
| B11A             | Pinehaven              | 1050 - 1250     | Pinehaven 1<br>Pinehaven 2               | 1352                | 0.21<br>0.50         | Pinehaven PP                                                                   | B9A                             |
| B9A              | Thornhill - Forestland | 875 - 1050      | Thornhill                                | 1117                | 0.19                 | Forest Park Res<br>Carisbrook Res<br>(Thornhill Reg)                           | B11B<br>B11B                    |
| B7A              | Joaquin Miller         | 675 - 875       | Swainland<br>Montclair<br>Joaquin Miller | 975<br>979<br>979   | 2.00<br>1.55<br>2.82 | Montclair PP<br>Joaquin<br>Miller PP                                           | B5A<br>B5A                      |
| B5A              | Dingee                 | 500 - 675       | Dingee<br>Estates<br>Burdeck             | 772<br>772<br>744   | 4.18<br>17.6<br>1.53 | Dingee PP<br>Estates PP<br>Summit S #3 PP                                      | G1Aa<br>B3A<br>G1Aa             |
| B4Aa             | Broadway Terrace       | 400 - 475       |                                          |                     |                      | Dingee Res<br>(Buena Vista Reg)<br>(Broadway Ter Reg)                          | B5A                             |





There are five regulators in the firestorm area:

- The Broadway Terrace pressure zone B4Aa receives its water through two pressure regulators (Broadway Terrace Regulator and Buena Vista Regulator), from the Dingee B5A zone.
- The Thornhill pressure zone (B9A) receives its water through one regulator (Thornhill Regulator), from the Carisbrook B11B zone.
- The Strathmoor pressure zone (A9B) can receive part of its fire flow water through the Bristol Regulator or the standby Caldecott Regulator, from the Gwin A11A or the Pinehaven B11A pressure zones.

Basically, each Cascade is a separate water system. Water stored in a reservoir in a particular pressure zone can be used within that pressure zone, or it can be pumped up to the next higher pressure zone, or water can drop down through a regulator into a lower zone. Generally, water from pressure zones at the same elevations cannot be transferred between Cascades, as there are no interconnecting pipes between the Cascades. In the Firestorm area, there is one interconnection between the A and B Cascades, from the B11A zone through the standby Caldecott regulator into the A9B zone. However, this standby regulator is normally closed, and was closed throughout the firestorm.<sup>2</sup>

Figure 3-4 shows the makeup of the distribution piping in the pressure zones serving the firestorm area. The miles of pipe shown in Figure 3-4 are for the entire pressure zones, parts of which were outside the firestorm area. [The values shown in the figures are considered accurate to within about  $\pm 5$  percent. The main points shown in Figure 3-4 are:

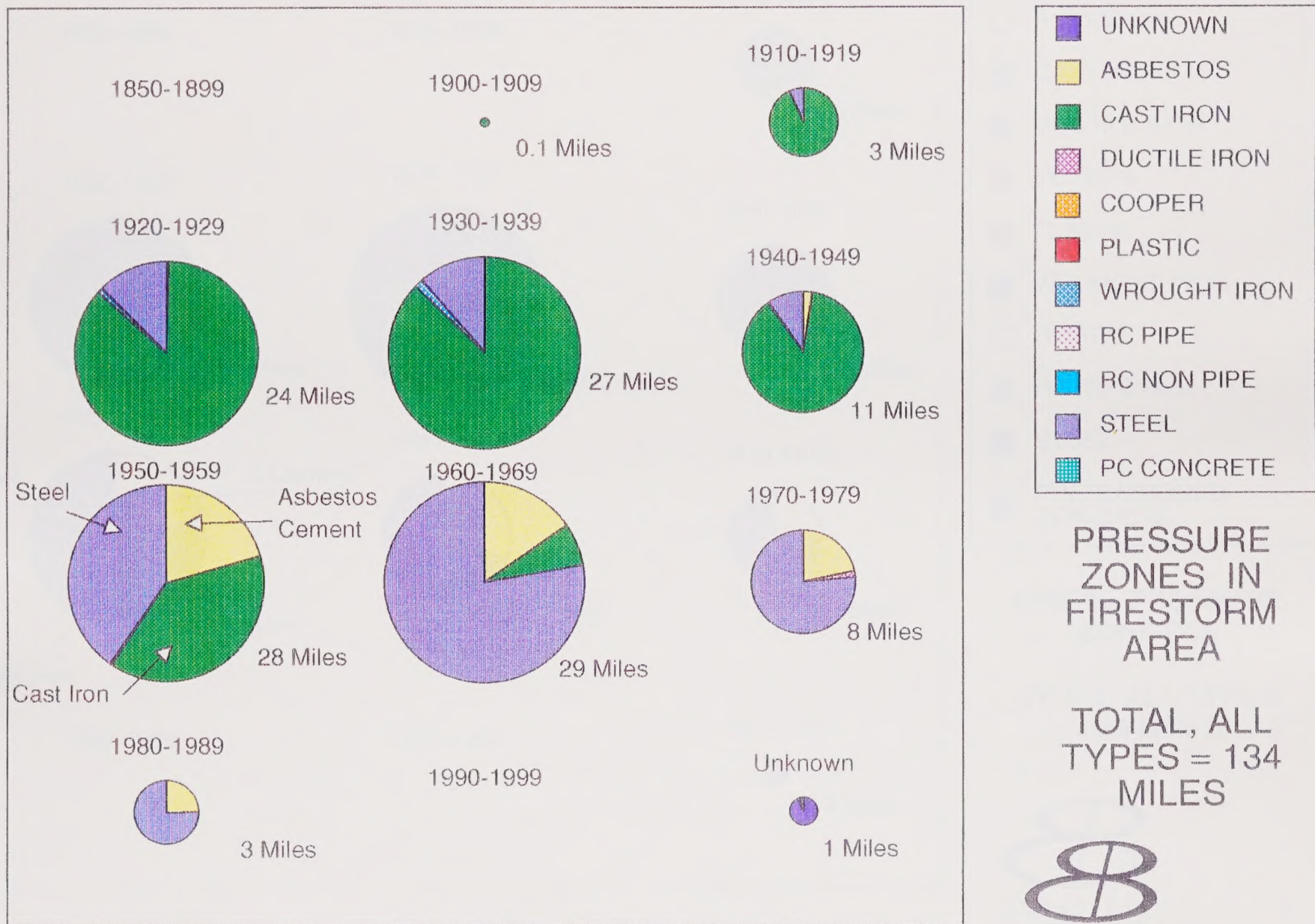
- The 11 fire-area pressure zones have about 134 miles of distribution pipe.
- Most of the pipe is either cast iron, steel or asbestos cement.
- Cast Iron pipe was the prime material in use prior to about 1950. Steel and asbestos cement pipe have been the prime materials in use after 1950.
- Only about 8% of pipe mileage in these zones was installed since 1970, which reflects that the water distribution system infrastructure in the firestorm area was basically complete by about 1969.
- About 70% of the pipe mileage in these zones is pre-1960 vintage.

The oldest parts of the pipe distribution system within the firestorm area date back to the early 1900s. The Dingee Reservoir, the Dingee (B5A) pressure zone and Broadway Terrace (B4Aa) pressure zone are the oldest parts of the system in the firestorm area. The age and type of pipe in the Dingee and Broadway Terrace pressure zones are shown in Figures 3-5 and 3-6, respectively. The pipe in these two zones is predominantly cast iron, with over 80% of the pipe in these two zones being pre-1960. Almost all the pre-1920 pipe in the entire firestorm area (3 miles total) is located in these two zones.





Figure 3-4



MILEAGES SHOWN NEXT TO PIES ARE TOTAL, ALL TYPES, BY DECADE

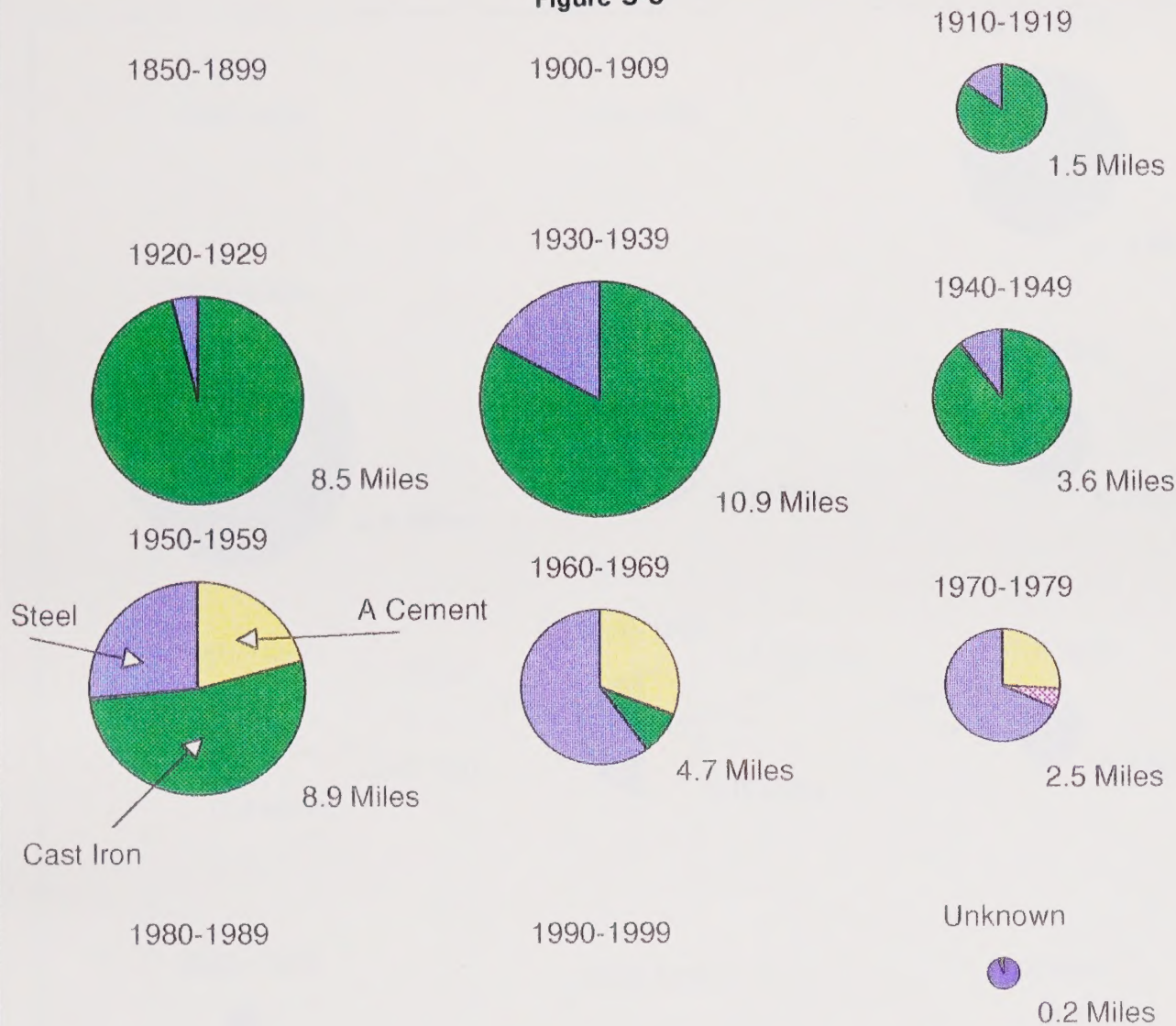


EBMUD





**Figure 3-5**



DINGEE PRESSURE  
ZONE B5A

TOTAL, ALL TYPES  
40.9 MILES

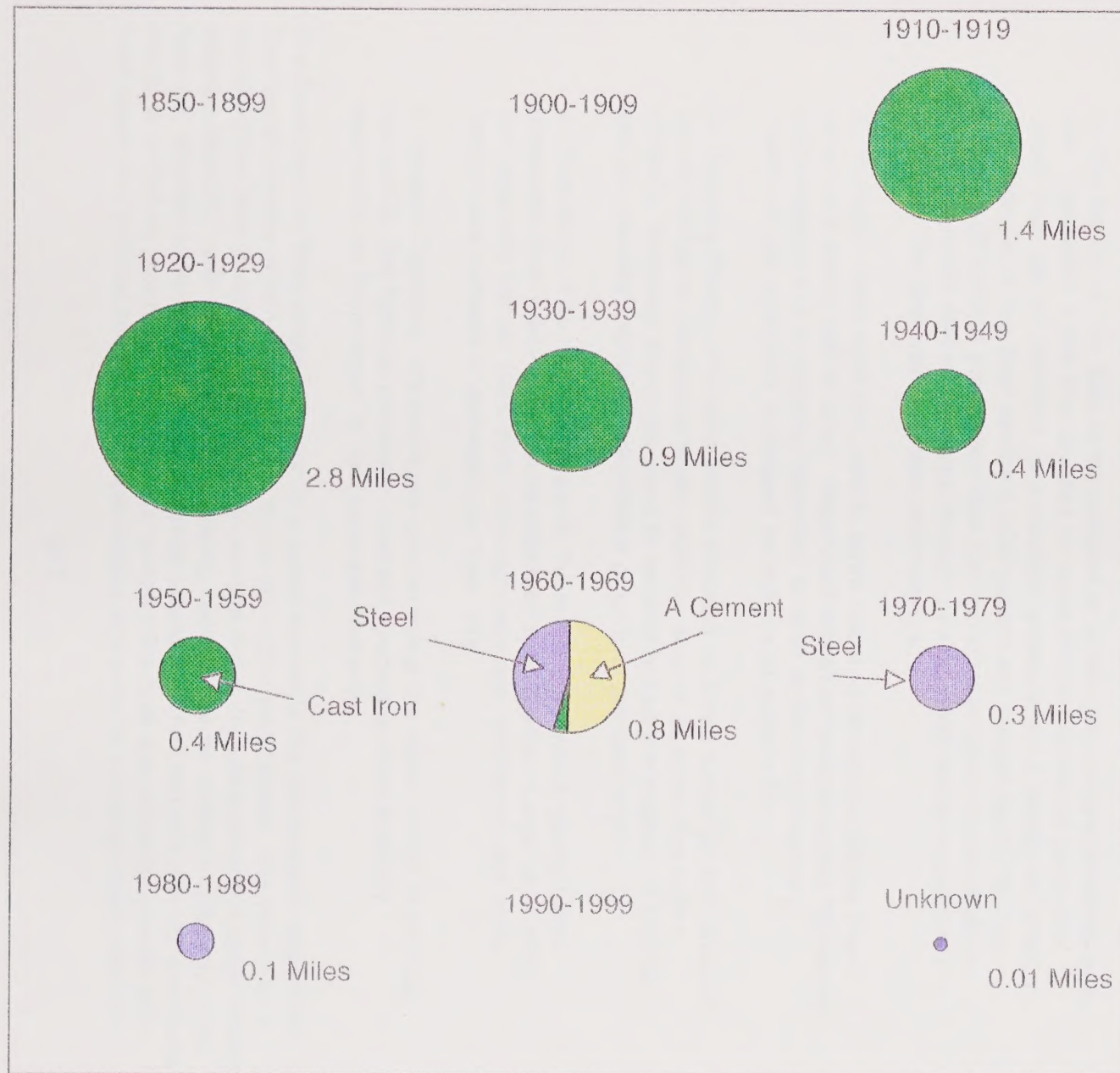


MILEAGES SHOWN NEXT TO PIES ARE TOTAL, ALL TYPES, BY DECADE





Figure 3-6



BROADWAY TERRACE  
PRESSURE ZONE B4Aa

TOTAL, ALL TYPES 7.1  
MILES



MILEAGES SHOWN NEXT TO PIES ARE TOTAL, ALL TYPES, BY DECADE





### 3.3 DESIGN CRITERIA, GUIDELINES, STANDARDS AND COMMON PRACTICES

#### 3.3.1 Introduction and Background

As discussed above in Section 3.2, various portions of the District's water distribution system have been built at different times. Design criteria, guidelines, standards, and common practices have evolved with time. In this section, we briefly describe various current and historical design criteria and guidelines which are applicable to water system design.

There are five elements of design which, in combination, largely determine how a water distribution system can respond to fire emergencies:

1. Fire flows. A fire flow is the amount of water that can be delivered to a fire. Generally, a fire flow is rated in terms of the number of gallons of water that can be delivered, at a residual pressure, for a particular duration. For example, a fire flow can be 1,000 gallons per minute (gpm) for two hours at 20 pounds per square inch (psi) residual pressure in the pipeline. Such fire flows can be delivered through one or more nearby hydrants to a particular fire (generally a single-structure fire) .
2. Storage. Reservoirs are used to store water at elevations higher than where the water will be used. Reservoirs are sized to store water for normal consumption and emergency reserves, as well as fire flow reserves. Reservoir size is usually expressed as millions of gallons (mg).
3. Pumping Plants. Pumping plants are used to pump water up into pressure zones located at elevations higher than the source of water ("pumped zones"). Pumping plants are sized to be able to pump a number of gallons per day, usually expressed as millions of gallons per day (mgd).
4. Pipe sizes. The size (diameter) of the water distribution piping helps determine how many gpm can be delivered to hydrants. Larger pipe sizes can generally deliver more gpm, although pipe age, gradients, and other factors can increase or decrease the flow rate.
5. Hydrant Spacing. Hydrants are spaced along the water mains to provide access for fire fighting purposes. Hydrant spacing is most typically expressed as the number of feet between hydrants.

Fire flows are the best single indicator of a water system's fire suppression capability. The design criteria which determine fire flows are highly interrelated. For example, a specified fire flow duration could be met in several ways, including having a large reservoir storage capacity, with relatively small pumping capacity, or by having a relatively small reservoir storage capacity, but larger pumping capacity. The District's current standards maintain sufficient reservoir water storage to meet fire flow standards by gravity flow from reservoirs without relying on the availability of power or pumping plant capacity.





### 3.3.2 Fire Flow Guidelines

Fire flow guidelines developed by the Insurance Services Office (ISO) are widely used throughout the United States. ISO is a private, fire-insurance-industry-supported service that grades municipalities for fire protection services. Insurance companies use this grading information in setting fire insurance premiums. The ISO, and its predecessor, the National Board of Fire Underwriters (NBFU) have developed a series of Guidelines by which they rate municipalities. The first such Guideline was prepared in 1916, and remained more or less unchanged through 1956<sup>6</sup>. There are also newer 1974<sup>4</sup> and 1980<sup>5</sup> editions of these guidelines.

As part of its comprehensive fire insurance rating system, the ISO evaluates fire flows from water systems. Fire flows are just one of the many variables considered in the final rating. For example, a city with low fire flows could still get a high rating because it has more apparatus, equipment and personnel than other cities, thus compensating for lower fire flows.

In following paragraphs, we review ISO fire flow guidelines, to provide one possible reference benchmark with which to compare the District's water distribution system fire flow capacity. It is important to note, however, that ISO fire flow guidelines are not standards and are neither required nor mandated; local jurisdictions may set design guidelines which are higher or lower than the ISO guidelines.

#### ISO Fire Flow Guidelines

The ISO has established fire flows which are required to meet their insurance grading/rating requirements:

"The required fire flow is the rate of flow needed for fire fighting purposes to confine a major fire to the buildings within a block or other group complex. The determination of this flow depends upon the size, construction, occupancy, and exposure of buildings within and surrounding the block or group complex; consideration may be given to automatic sprinkler protection."

"A required fire flow shall be determined at appropriate locations in each district or section or the municipality. The minimum fire flow requirement is 500 gpm and the maximum for a single fire is 12,000 gpm."<sup>3</sup>

Minimum fire flows (500 gpm) apply to low-density residential areas, while the maximum fire flows (12,000 gpm) apply to downtown areas with high-density, multi-story buildings.

In the ISO's 1974<sup>4</sup> and 1980 editions,<sup>5</sup> the suggested fire flows for one- and two-family dwellings not exceeding two stories are as follows:





**Table 3-2**  
**ISO Fire Flow Guidelines for Residential Areas**

| <u>Exposure Distances</u> | <u>Suggested Required Fire Flow</u> |
|---------------------------|-------------------------------------|
| Over 100 feet             | 500 gpm                             |
| 31 - 100 feet             | 750 gpm                             |
| 11 - 31 feet              | 1,000 gpm                           |
| 10 feet or less           | 1,500 gpm                           |

Exposure distances are the distance to the nearest adjacent structure. These ISO fire flows all assume single structure fires with fire hydrants within 1000 feet (measured as hose can be laid by apparatus) of the front of the structure.<sup>5</sup> The minimum required duration for these fire flow is two hours.

Because portions of the fire area were developed many years ago, it is informative to review historical ISO guidelines.<sup>6,7</sup> For residential districts (such as the entire firestorm area), the ISO fire flow guidelines were based upon the structural conditions and congestion of the buildings. For example, from about 1940, the guidelines for residential areas were as follows. In districts with about one-third of the lots in a block built upon having buildings of small area and of low height, at least 500 gpm is required; if the buildings are of larger area or height, up to 1,000 gpm is required; where districts are closely built or the buildings approach the dimension of hotels or high value residences, 1,500 gpm to 3,000 gpm is required. Early ISO additions also included fire flow guidelines for cities as a whole, based on population.<sup>7</sup> However, these population-based guidelines were abandoned by ISO because they proved to be not useful in rating fire suppression capabilities.

#### **Other Fire Flow Guidelines**

Cities may adopt the Uniform Fire Code like they adopt building codes. The Uniform Fire Code is, however, more flexible than the ISO guidelines in determining what fire flows are required. The Uniform Fire Code allows local jurisdictions considerable latitude in establishing fire flow durations and minimum residual pressures. Today, the Oakland and Berkeley Fire Departments specify fire flows of 1,500 gpm for two hours for new construction in the hills areas.

#### **3.3.3 Pre-EBMUD Designs (Broadway Terrace and Dingee Pressure Zones)**

Within the fire area, the Broadway Terrace (B4Aa) and Dingee (B5A) pressure zones contain the oldest portions of the water distribution system (see Section 3.2). Substantial portions of these pressure zones were built prior to the formation of the District in 1928. In this section, we describe the possible fire flow guidelines in use at time of construction of the water distribution system in the Broadway Terrace (B4Aa) and Dingee (B5A) zones.

The Dingee reservoir and local water distribution system was built by Mr. Dingee, in the 1890s, some 30 years prior to the formation of the District. The Broadway Terrace





(B4Aa) pressure zone was originally called the Dingee Regulated zone, and was presumably also designed by Mr. Dingee.

The standards that Mr. Dingee used to build this system are not known. Personnel interviewed as part of this effort did not know of factual data which describe fire flow standards from this era, nor did they know if the system was designed to meet those standards. We found no documented evidence of the fire flow standard in use when the distribution pipes in the B4Aa and B5A zones were built. It is possible that no minimum fire flows were contemplated by Mr. Dingee when he built the original system.

The oldest (1916) ISO (its predecessor, the National Board of Fire Underwriters) guidelines have a minimum fire flow of 500 gpm for 2 hours, (60,000 gallons). However, much of the original infrastructure was already in place by 1910. The infrastructure in place in 1930 indicates that at least three pressure zones had tanks sized under 40,000 gallons, suggesting that a fire flow standard of 500 gpm for 2 hours may not have been used in design of these areas. Even with the small storage capacity reservoirs, however, fire flows of 500 gpm for 2 hours could possibly have been available, depending on the pumping capacities and interconnects available in the pre-1930 system.

There is uncertain evidence as to what fire flow standards or guidelines were used to build the original infrastructure in the B4Aa and B5A pressure zones. However, it is important to note that since the original construction, storage capacity and other water distribution system infrastructure have been substantially upgraded in these zones and throughout the older portions of the system in the fire area. For example, as shown in Table 3-3, the total water storage capacity in the hills area was increased by a factor of 16 between 1930 and 1991.

Table 3-3

Water Storage Capacities, 1930 and 1991

| Reservoir Name                                         | 1930 Capacity (Millions of Gallons) | 1991 Capacity (Millions of Gallons)                                                  |
|--------------------------------------------------------|-------------------------------------|--------------------------------------------------------------------------------------|
| Gwin                                                   | 0.10                                | 0.50                                                                                 |
| Claremont Heights                                      | 0.04                                | 0.50 (Amito)                                                                         |
| Pinehaven No. 2                                        | 0.04                                | 0.50 (No. 2)<br>0.20 (No. 1)                                                         |
| Pinehaven No. 1                                        | 0.20                                | Relocated at Pinehaven No. 2                                                         |
| Thornhill                                              | 0.02                                | 0.19                                                                                 |
| Other Tanks installed since 1930 within Firestorm area |                                     | 0.40 Sherwick<br>0.50 Strathmoor<br>0.25 Hilltop<br>1.50 Summit S.<br>2.00 Swainland |
| TOTAL STORAGE                                          | 0.40 MG                             | 6.54 MG                                                                              |





### 3.3.4 EBMUD Design Practices

District design practices as of 1940 were reviewed in an article<sup>7</sup> by R.C. Kennedy, a former Assistant Chief Engineer in the District. Water demand for residential areas was estimated using the "depth over area" method, based on lot sizes, amount of landscaping and other factors. Fire flow needs, based on the National Board of Fire Underwriters guidelines, were considered in the design process. Mr. Kennedy noted that storage requirements for fire flows could be met in several ways, involving combinations of storage within a zone, pumping capacities, and storage outside of a zone available by interconnects between zones.

Over the last several decades, the District has developed a set of Engineering Standard Practices (ESPs) for use by the District in planning and building water distribution systems. These ESPs cover a wide range of topics, including cost estimation, drafting, surveying, and many other topics. Our review has found the oldest ESPs dating from the mid-1950s, covering a few topics. Since then, many more ESPs have been developed to cover additional topics, and older ESPs have been revised. As of February, 1990, there are 99 current ESPs.<sup>8</sup>

Two District ESPs cover four of the five elements of design which, in combination, largely determine how a water distribution system can respond to fire emergencies (see Section 3.3.1). ESP 492.1<sup>9</sup> covers minimum fire flows and pipe sizes. ESP 492.2<sup>10</sup> covers pumping plants and storage. These ESPs are summarized in Table 3-4. Previous versions of these two ESPs are dated from 1979<sup>11, 12</sup>. The 1979 versions were the first issue of these standards.

**Table 3-4  
District Standard Practices**

| CURRENT STANDARDS | Fire Flow                                                                                                                                                                                                                                                                                                                                                                         | Pipe Sizing                                                                                                                                               | Pumping Plants                                                                                                                                                                  | Storage                                                                                                                                         |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| EBMUD 1985        | Specified by fire agency.<br>If fire agency does not specify fire flow, then use a minimum of 1,000 gpm for 2 hours; 500 gpm allowed for extensions to a single premise or small development; if min. fire flows cannot be met without significant upgrades, and the applicant and firefighting agency are so notified<br><br>(1,500 gpm for 2 hours in Oakland - Berkeley Hills) | 6 inch minimum<br>4 inch allowed in cul de sac if no hydrants needed<br><br>20 psi residual for fire flow + max. demand                                   | Pump to meet 1.5 times Maximum Day Demand<br><br>At least one spare pump<br><br>In larger zones, try to plan for more than one pumping plant in separate parts of the PG&E grid | 1.5 times maximum day demand plus fire flow x duration<br><br>Minimum storage for any pressure zone is 300,000 gallons                          |
| EBMUD 1979        | 1000 gpm for 2 hours or higher if required by local fire agency                                                                                                                                                                                                                                                                                                                   | 8 inch min. in high-density, or long streets without side connections such as on terraced hillsides<br><br>2 or 4 inch min on cul-de-sac without hydrants | Pump to meet 1.0 times Maximum Day Demand.<br><br>At least one spare pump<br><br>24 hour recovery of an empty reservoir or Max. Day Demand, whichever is greater                | 2.0 times maximum day demand<br><br>Minimum storage for any pressure zone 300,000 gallons (increase to 500,000 gallons in hazardous hill areas) |





The fifth element of design (hydrant spacing) is specified by the local fire jurisdiction agency (the Oakland and Berkeley Fire Departments). As specified in EBMUD Procedure 8-76<sup>13</sup>, fire flows and hydrant spacing are set by the responsible fire department or district.

Currently, the Oakland Fire Department has set 1,500 gpm for two hours as the required fire flow for new construction in the Oakland Hills area east of Highway 13. The Berkeley Fire Department has the same required fire flow in this area.<sup>14</sup> In the following section, recent major District projects in the firestorm area are reviewed to determine if recent projects have conformed to these fire flow standards.

### **3.3.5 EBMUD Adherence to Fire Flow Standards**

As described in the following paragraphs, the District has installed five new reservoirs, in or near the firestorm area over the past 19 years. The need for these new reservoirs was generated by the District's concern for fire fighting needs, as well as the additional new houses constructed in the developing Hiller Highlands area.

When the District installed these water storage reservoirs and related hardware in these pre-built residential areas, other needs of the local community had to be considered. For example, the District faced considerable challenges in designing and installing the recently built Pinehaven No. 2 and Sherwick reservoirs. The environmental impact review (EIR) process generated opposition to the construction of these reservoirs by local residents. Modifications to the designs and lengthy times were involved before the designs were finally completed. Many of the written submittals by local residents<sup>15</sup> were against the construction of the facilities. Typical concerns raised by residents included disturbed sight lines and the disruptions involved in the construction process.

This section reviews fire flow design standards for recent major projects in the fire area pressure zones. The possible design fire flows for each of these 11 pressure zones are assessed.

### **1973 Upgrades of the A13B, B13Aa and B13A Pressure Zones**

In 1973, EBMUD installed three new facilities in or near the firestorm area: the Berkeley Hills (A13B), Hilltop (B13Aa) and Roundtop (B13A) reservoirs and related facilities. These three reservoirs were installed partially as a result of the 1970 Claremont Canyon fire, (which destroyed 37 homes and burned 204 acres), and partially because of a severe freeze in the winter of 1972, which increased the fire hazard. When installed, these three reservoirs were designed primarily to serve as emergency reservoirs for fire fighting purposes (a few residences were served from the Hilltop reservoir). By 1983, there was an increased interest in construction of new residences in these pressure zones, and the District prepared an Environmental Impact Report to study this prospective development.<sup>15</sup> In this report, the District indicated that the fire flow design standard used for these reservoirs was 1,500 gpm for two hours. Therefore, the District did design these upgrades to current Oakland and Berkeley fire flow standards.





### **1988 Upgrades of the A9B, A7B and B11A Pressure Zones**

Since 1988, the District designed and installed two new reservoirs and upgraded distribution piping and related facilities in part of the firestorm area. The two new reservoirs are the 0.4 million gallon Sherwick (A7B Amito zone) and the 0.5 million gallon Pinehaven No. 2 (B11A zone). A new stretch of pipeline was installed from the Strathmoor Reservoir (A9B) to the former A9Aa regulated zone. The District used a fire flow requirement of 1,500 gpm for two hours when designing these upgrades. Through the Environmental Impact Report process<sup>15</sup>, the Oakland Fire Department reviewed and accepted this fire flow design<sup>16</sup>. Therefore, the District did design these upgrades to Oakland's current fire flow standard.

### **Summary Comments: Design Standards for the 11 Fire-Area Pressure Zones**

The scope of this work has precluded a comprehensive review to determine the exact design criteria used, if known, for the entire fire area. However, based on available information, it is clear that substantial portions of the water distribution system in the fire area were apparently designed to meet the current fire flow standard of 1,500 gpm for 2 hours. Meeting this standard requires sufficient water storage within pressure zones (or availability of other water sources) as well as a distribution piping system with sufficient capacity to support these fire flows. Other portions of these zones, however, were clearly not designed to current fire flow standards.

A comprehensive document search was not conducted to confirm whether the Joaquin Miller (B7A), Thornhill-Forestland (B9A), Summit (A5A) pressure zones were designed to today's standard of 1,500 gpm for 2 hours. However, for these three pressure zones, the size of the reservoirs and minimal amount of small diameter pipe suggest that these zones were designed to meet this standard.

With the relatively recent upgrades in storage capacity (see above), it appears that newer portions of the Berkeley Hills (A13B), Strathmoor (A9B), Amito (A7B), Hilltop (B13Aa), and Pinehaven (B11A) pressure zones also were designed to meet current fire flow standard. For the Gwin (A11A) pressure zone, the current reservoir size and distribution pipe system are compatible with portions of this zone being designed for the current 1,500 gpm for 2 hours standard.

As discussed in preceding sections, older portions of the Dingee and Broadway Terrace pressure zones were not originally designed or built to meet current fire flow standards.

### **3.3.6 Standards in Use at Other Water Agencies**

Several other water agencies were surveyed to collect information as to their current standards in water distribution system design for residential neighborhoods. These water agencies include: 1) Alameda County Water District, 2) Contra Costa County Water District, and 3) Marin Municipal Water District. Table 3-5 summarizes this survey. This





**Table 3-5**  
**Local Water Agencies Standard Practices**

| CURRENT STANDARDS                  | Fire Flow                                                                          | Pipe Sizing                                                                                  | Pumping Plants                               | Storage                                                                                        |
|------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------|
| Alameda County Water District      | 1500 gpm<br>X hour duration<br>X set by Water District and approved by fire agency | 6 inch minimum up to 1000 feet long<br>8 inch minimum for dead ends                          | Pump to meet fire flow                       | Maximum Day + Fire<br>Minimum size 500,000 gallons<br>Assume 1800 gallons per day per dwelling |
| Contra Costa County Water District | Set by fire agencies of each city served                                           | 6 inch mains minimum<br>4 inch allowed for short cul de sacs<br><br>20 psi residual pressure | Pump to meet fire flow                       | Fire flow + residential demand                                                                 |
| Marin Municipal Water District     |                                                                                    | 6 Inch mains minimum loops req'd if ≥ 16 units<br>4 inch allowed in short cul de sac         | Pump to replace daily consumption in 8 hours | Two summer days consumption                                                                    |

**Table 3-6**  
**Comparisons of Average Daily Use and Treated Water Storage**  
**for Various Water Agencies in the San Francisco Bay Area, 1981**

| Agency                              | Average Daily Use, MGD | Treated Water Storage, MG | Ratio of Volume of Storage to Average Daily Use |
|-------------------------------------|------------------------|---------------------------|-------------------------------------------------|
| Alameda County Water District       | 30.5                   | 63                        | 2.1                                             |
| City of Antioch                     | 6.8                    | 9.5                       | 1.4                                             |
| California Water Service Co.        |                        |                           |                                                 |
| Livermore                           | 6.3                    | 9.8                       | 1.6                                             |
| Los Altos/Cupertino                 | 11.5                   | 13.4                      | 1.2                                             |
| San Carlos                          | 4.0                    | 5.8                       | 1.4                                             |
| San Mateo                           | 11.4                   | 14.5                      | 1.3                                             |
| South San Francisco                 | 7.3                    | 7.1                       | 0.97                                            |
| Contra Costa County Water District  | 27.8                   | 51.9*                     | 1.9                                             |
| East Bay Municipal Utility District | 193.5                  | 794                       | 4.1                                             |
| City of Hayward                     | 14.0                   | 23.7                      | 1.7                                             |
| Marin Municipal Water District      | 25.4                   | 53.5                      | 2.1                                             |
| San Jose Water Works                | 119                    | 237*                      | 2.0                                             |

\*Note: Elevated tanks only





Based upon the results of these surveys, we conclude that EBM





### 3.4 PRE-FIRE STATUS OF THE WATER DISTRIBUTION SYSTEM

This section reviews the status of the water distribution system immediately before the fire began spreading rapidly. At 11:00 am on Sunday October 20, 1991, the water distribution system in the fire area was in normal operating status. Reservoirs in or near the fire area had been refilled overnight (if necessary) and were nearly full, at 78% to 98% of capacity. Data on reservoir water storage in gallons and as percentages of reservoir capacity are given below in Table 3-7. In some cases (for example, Amito) where reservoirs were at less than 90% of capacity, the reservoir level is indicative of pumping to refill reservoirs higher in the cascade.

**Table 3-7**  
**Reservoir Status at 11:00 am October 20, 1991**

| Zone Designation | Zone Name              | Reservoir Name | Reservoir Capacity (MG) | Percent Full, 11:00 am October 20, 1991 |
|------------------|------------------------|----------------|-------------------------|-----------------------------------------|
| A13B             | Berkeley Hills         | Berkeley Hills | 0.40                    | 90%                                     |
| A11A             | Gwin                   | Gwin           | 0.50                    | 97%                                     |
| A9B              | Strathmoor             | Strathmoor     | 0.50                    | 95%                                     |
| A7B              | Amito                  | Amito          | 0.49                    | 78%*                                    |
|                  |                        | Sherwick       | 0.40                    | 90%                                     |
| A5A              | Summit                 | Summit S       | 1.50                    | 82%                                     |
| B13Aa            | Hilltop                | Hilltop        | 0.25                    | 93%                                     |
| B11A             | Pinehaven              | Pinehaven 1    | 0.21                    | 98%                                     |
|                  |                        | Pinehaven 2    | 0.50                    | 97%                                     |
| B9A              | Thornhill - Forestland | Thornhill      | 0.19                    | 97%                                     |
| B7A              | Joaquin Miller         | Swainland      | 2.00                    | 90%                                     |
| B5A              | Dingee                 | Dingee         | 4.18                    | 82%                                     |
|                  |                        | Estates        | 17.6                    | 90%                                     |

\* 94% at 8:00 am. Drawdown reflects filling of Strathmoor reservoir between 8:00 am and 11:00 am.

Recent single pressure zone reservoir design capacities are the sum of three quantities: 0.5 times maximum daily demand (for normal use), an emergency reserve of 1.0 times maximum daily demand, plus a fire-fighting reserve of 180,000 gallons or more. These water quantities for a typical 0.5 million gallon reservoir are shown in Figure 3-7.

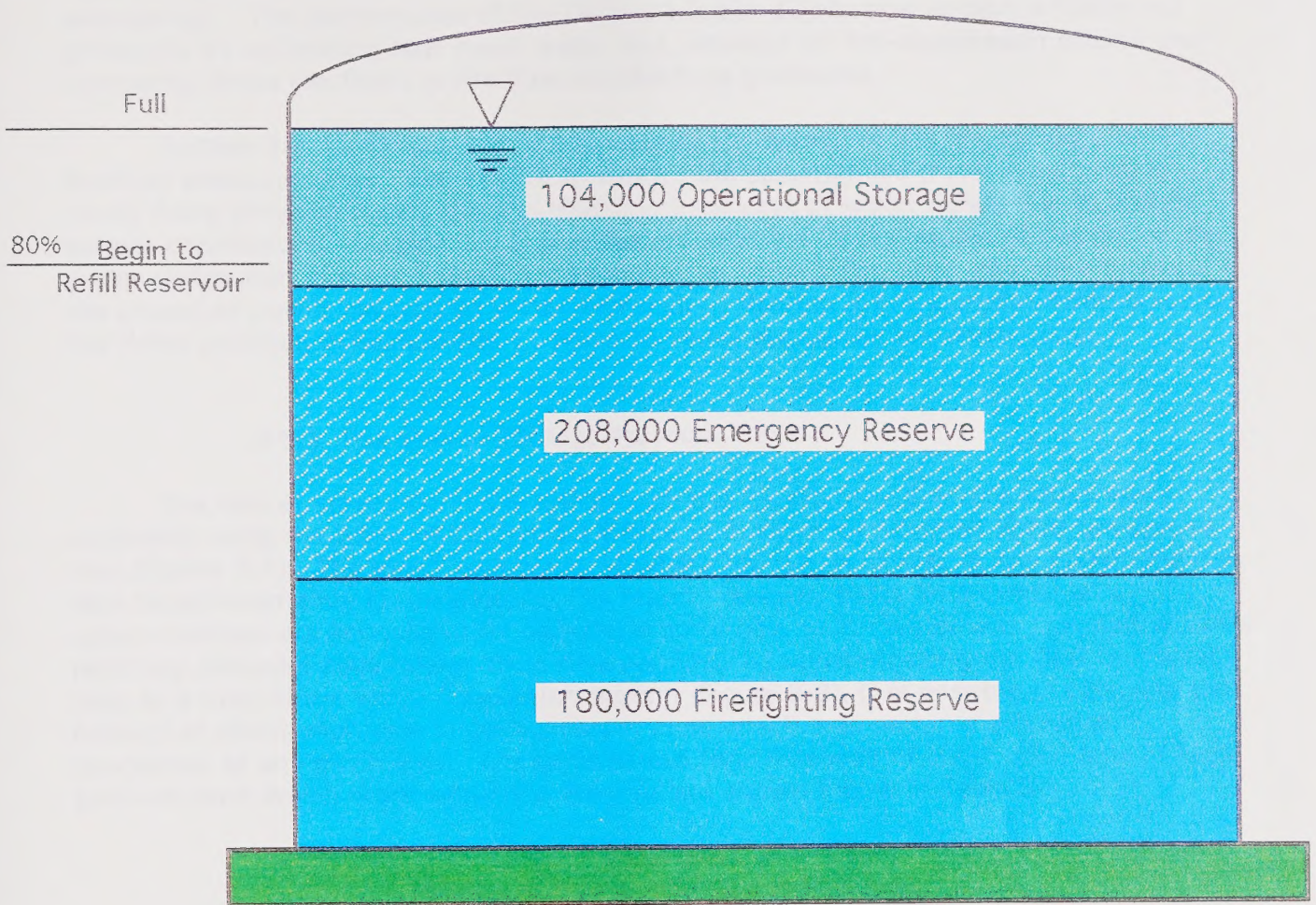
The design criteria for these reservoirs are not all known. However, a fire-fighting reserve of 180,000 gallons suffices to meet the current fire flow standard of 1,500 gpm for 2 hours. Therefore, as shown in Table 3-7, all of these reservoirs had sufficient water to meet the current fire-flow standard. Except for Hilltop and Thornhill, all of the fire area reservoirs had more than double the typical fire-fighting reserve of 180,000 gallons. For the Thornhill pressure zone, additional water was available through the Thornhill regulator from the 3.4 million gallon Carisbrook Reservoir. For the Hilltop pressure zone, as discussed in Section 3.5.4, available water resources sufficed to halt the spread of the fire in the zone by 1:00 pm on October 20th.





Figure 3-7

## RESERVOIR DESIGN CAPACITY DIAGRAM



TYPICAL HILL AREA RESERVOIR STORAGE  
(Capacities in gallons)  
(For a pressure zone served by a single pumping plant)





### 3.5 PERFORMANCE OF THE WATER DISTRIBUTION SYSTEM DURING THE FIRE

In this section, we begin to address the second question posed in this assessment: How well did the District's water distribution system respond during the firestorm emergency?. The performance of the District's water distribution system is measured principally by estimating how much water was provided for fire-suppression efforts and comparing these fire flows to fire flow standards or guidelines.

Section 3.5.1 provides a brief overview of the spread of the fire through the 11 involved pressure zones. Section 3.5.2 reviews the assumptions made in calculating water flows provided during the fire, including estimates of water losses due to broken service connections. Section 3.5.3 provides an overview of the impact of the fire on the water distribution system, including information on when some reservoirs were empty and the impact of power outages on water availability. Section 3.5.4 compiles information on fire flows provided in each of the 11 pressure zones during the fire emergency.

#### 3.5.1 Fire Spread Through Pressure Zones

The rate of spreading of the fire through the 11 affected pressure zones was estimated using the State of California's Office of Emergency Services (OES) fire-spread map (Figure 2-1). The exact boundaries of where the fire front was at any given time may only be approximately represented by this map: however, these best-available approximations are acceptable for consideration of how much water was provided within a particular pressure zone during given time periods. By superimposing the OES firespread map on a map of the water distribution system (Figure 3-8), it is possible to calculate the mileage of distribution pipe in each pressure zone which was within the firestorm boundaries at any given time. The approximate total mileages of distribution pipe in each pressure zone which were within the fire area are shown below in Table 3-8.

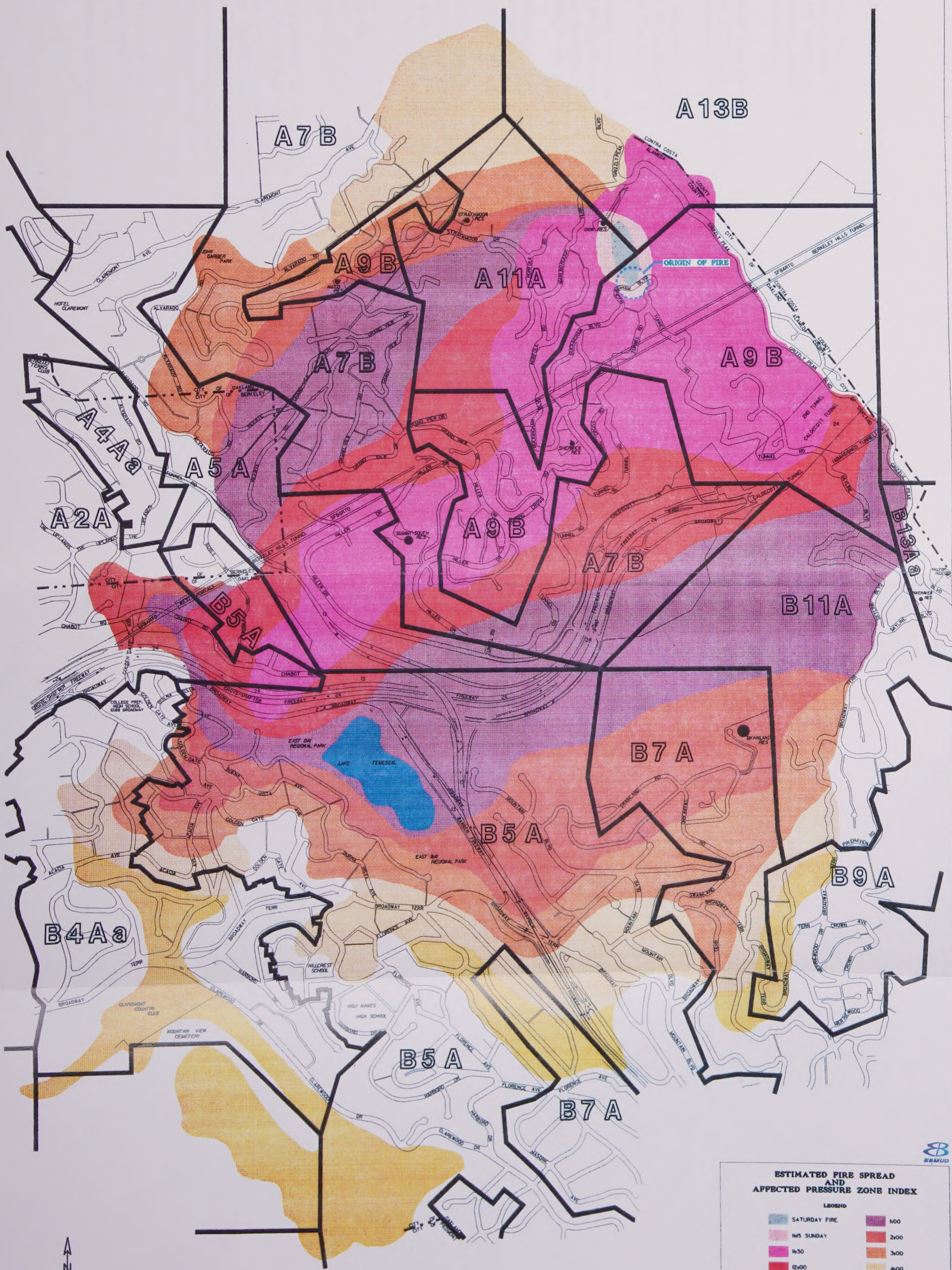
**Table 3-8**  
**Mileage of Distribution Pipe in Fire Area**

| <u>Zone</u> | <u>Zone Name</u>     | <u>Pipe Mileage<br/>in Fire Area</u> | <u>Total Pressure<br/>Zone Mileage</u> | <u>Percent in Fire</u> |
|-------------|----------------------|--------------------------------------|----------------------------------------|------------------------|
| A13B        | Berkeley Hills       | 0.15                                 | 0.92                                   | 16                     |
| A11A        | Gwin                 | 1.77                                 | 1.77                                   | 100                    |
| A9B         | Strathmoor           | 4.23                                 | 4.44                                   | 95                     |
| A7B         | Amito                | 5.75                                 | 6.5                                    | 88                     |
| A5A         | Summit               | 1.84                                 | 27.4                                   | 7                      |
| B13Aa       | Hilltop              | 0.65                                 | 1.0                                    | 65                     |
| B11A        | Pinehaven            | 0.31                                 | 2.27                                   | 14                     |
| B9A         | Thornhill-Forestland | 0.44                                 | 10.67                                  | 4                      |
| B7A         | Joaquin Miller       | 2.55                                 | 28.5                                   | 9                      |
| B5A         | Dingee               | 8.90                                 | 40.11                                  | 22                     |
| B4Aa        | Broadway Terrace     | 1.21                                 | 6.86                                   | 18                     |









**FIGURE 3-8**

SCALE: 1" = 1000'

THIS MAP IS COMPILED FROM UNCHECKED VENDOR GENERATED FILES AND FROM TENTATIVE POSTED DATA. IT IS INTENDED FOR GENERAL REFERENCE INFORMATION ONLY. IF DISCREPANCIES ARE FOUND PLEASE CONTACT THE MAPPING UNIT.

OAKLAND/BERKELEY FIRESTORM  
FIRE SPREAD AREA

REVISION: 11/15/2006  
DATE: 11/15/2006  
BY: J. L. HARRIS  
CHECKED: J. L. HARRIS  
DATE: 11/15/2006  
BY: J. L. HARRIS





### 3.5.2 Water Usage Calculation Methodology

For each of the eleven pressure zones, the approximate amount of water used in each zone has been calculated for the 30 hour period beginning at 8:00 am Sunday morning, October 20, 1991, through 2:00 pm Monday afternoon, October 21, 1991. The methodology used to calculate the approximate amount of water used in a particular pressure zone is given below.

- For each time period considered (60 minutes), the net water supplied to a pressure zone equals the difference between the total water supplied into the zone and the total water supplied out of the zone.
- The total water into a zone is the sum of water drawn down from the reservoir(s), water supplied by a regulator (from another zone), and water pumped into the zone by permanent or emergency pumps.
- The total water out of a zone is the sum of water added to the reservoir(s) (if the reservoir level went up during the time period), water supplied to a regulator (for another zone) and water pumped out of a zone by permanent or emergency pumps.
- Not all of these factors are applicable to each zone, but considering all of these factors includes all of the possible inputs/outputs of water to/from a pressure zone.

The above formula indicates how much water was provided in each pressure zone: it does not indicate the purposes for which the water was used. To estimate water used for fire-fighting purposes, estimates of other uses must be subtracted from the calculated total water provided in each zone. Total water usage in a zone is the sum of water used:

- 1) for normal residential purposes (drinking, irrigation),
- 2) for civilian fire fighting (wetting down roofs with garden hoses),
- 3) from broken service connections at burned houses, and
- 4) for fire fighting by fire departments.

The District's OP/NET system data were used to obtain most of the information for these calculations. The OP/NET system is a real time data acquisition and control system used by the District to monitor reservoir levels and pumping plant flows in the water distribution system. OP/NET data is collected from transmitters located at many locations in the water distribution system, including all major reservoirs and pumping plants. During the firestorm, power outages caused some information from some of these transmitters to be lost. After power was lost to the OP/NET system, judgments were made about the rate of water level increase or decrease, based upon the last recorded rate of water usage.

The OP/NET system does not collect information at all locations. The available OP/NET information was augmented with data from these additional sources:

- Circular charts showing pumping plant performance,





- Reservoir level readings reported by EBMUD personnel, and logged in the Operations Control Center (OCC) logs during the October 20 - 21 time period (these estimates are considered accurate only to about one foot of reservoir elevation), and
- After action reports from fire departments, where reports of water availability and pressure are noted at particular times and locations.

The District does not currently maintain flow or pressure data acquisition systems for the five pressure regulators in the firestorm area. To determine the amount of water passing through a pressure regulator at a given time, assumptions were made as to the likely rate of flow, based upon availability of water in the upstream reservoir, and the estimated fire fighting demands in the pressure zone. These estimates are considered accurate only to about  $\pm 500$  gallons per minute (gpm).

The accuracy of water use estimates varies with time and pressure zone, depending on many variables including OP/NET data availability, reservoir size, and whether or not water supply was controlled by regulators and manually field-operated zone gates. Estimates for zones with smaller reservoirs tend to be more accurate because a given uncertainty in reservoir elevation corresponds to fewer gallons than would be the case in larger reservoirs. Estimates for zones without regulators are more accurate because of the roughness of regulator flow estimates. For any given pressure zone, the estimate of total water provided is more accurate than are individual estimates per hour. Likewise, estimates for total water used in a cascade are more accurate than estimates for individual zones, because total water in a cascade is well-determined (if the estimated water provided in one zone is too high, then the estimate in another zone up or down the cascade will be too low).

One substantial uncertainty in water usage estimates is the amount of water lost due to broken services. When houses burned, the service connections from the distribution main to the houses often flowed water because they were damaged or melted.

Under normal conditions, a single 5/8 inch service connection can provide about 20 gpm to a house. Many houses in the firestorm area have larger service connections (3/4 and 1 inch connections are not uncommon - larger connections, from 2 - 6 inches, supply a few customers, such as schools and apartments). During the firestorm, however, lesser amounts of water would have flowed through open service connections, because of competing demands for water from fire fighters (and other open service connections). Also, not all service connections were likely to be completely open.

Beginning at about 3:00 pm on October 20, 1991, District personnel began closing off the taps off the distribution mains to these failed service connections. This effort lasted until about 7:00 pm that evening, when it became too dark to continue safe operations. The four hour effort to close off service connections, on October 20, 1991, was concentrated around the Hiller Drive area, serving the A7B Amato and A9B Strathmoor zones.<sup>18</sup> Beginning at about 8:00 am on October 21, 1991, District personnel began closing off the taps to failed service connections in the B Cascade. By about 3:00 pm October 21, 1991, District personnel had closed off over 2,000 service connections.





Approximately one-quarter to one-third of all water used during peak water usage times may have been lost through failed service connections. This estimate is consistent with the allowance for loss of water used in developing ISO rating guidelines for fire flows. Water usage data from Cascade B show a decrease in water usage during the period beginning at 8:00 am on October 21 when District personnel were closing off service taps. In part, this decrease may also represent reductions in fire-fighting efforts over the same time period. Very roughly, however, this decrease in water usage suggests that one-quarter to one-third of total water usage at peak demand times may have been attributable to losses from broken services.

### 3.5.3 Summary of Impacts of the Fire Emergency on the Water System

#### Empty Reservoirs

Due to extreme (above design basis) water demand during the firestorm, several reservoirs were emptied for varying periods of time. Because of power outages, data from the District's OP/NET system are incomplete and the exact times when reservoirs emptied are not known. Based on the best available data, including fire department after-action reports, Table 3-9 provides the estimated times that reservoirs were empty (to the closest hour or best available time).

**Table 3-9  
Empty Reservoirs**

| Zone  | Reservoir Name            | Empty Duration                                                                                                                               |
|-------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| A5A   | Summit South Res          | 5:00 pm until 6:00 pm 10/20<br>Midnight until 3:00 am 10/21<br>6:00 am 10/21, for less than 1 hour                                           |
| A7B   | Amito Res<br>Sherwick Res | 2:30 pm 10/20 until 10:00 am 10/21<br>2:30 pm 10/20 until 10:00 am 10/21                                                                     |
| A9B   | Strathmoor Res            | 3:00 pm 10/20 until after 2:00 pm 10/21                                                                                                      |
| A11A  | Gwin Res                  | 2:00 pm 10/20 until after 2:00 pm 10/21                                                                                                      |
| B7A   | Swainland Res             | 5:00 pm until 6:00 pm 10/20<br>2:00 am 10/21 until 2:00 pm 10/21                                                                             |
| B9A   | Thornhill Res             | 5:00 pm 10/20 - 12:00 noon 10/21                                                                                                             |
| B11A  | Pinehaven No. 1 Res       | 8:00 pm 10/20 until after 2:00 pm 10/21                                                                                                      |
| B11A  | Pinehaven No. 2 Res       | 8:00 pm 10/20 until after 2:00 pm 10/21<br>After action fire reports suggest that the reservoirs may have been empty at about 7:00 pm 10/20. |
| B13Aa | Hilltop Res               | 5:00 pm 10/20 until after 2:00 pm 10/21<br>Assumed empty at 5:00 pm based on after action fire report.                                       |





### Effects of Power Outages

As discussed in Section 3.2, the reservoir system in the hills area is cascaded, with higher elevation reservoirs supplied by pumping from lower elevation reservoirs. Electric power failures temporarily shut down eight pumping plants in or near the fire area. Table 3-10 summarizes data on the power outages at these pumping plants and the types of emergency equipment (portable pumps or emergency generators) in use at the affected pumping plants.

The Potential Pumping Rate column in Table 3-9 is the maximum capacity of each pumping plant, assuming that all pumps are available, including spares, at their rated capacities.<sup>19</sup> Since each pumping plant draws water from the pressure zone below, these pumping values are not cumulative. For example, if the Amito pumping plant were pumping 1,250 gpm from Summit South into Amito, and the Strathmoor pumping plant were pumping 700 gpm from Amito into Strathmoor, then the Amito pressure zone only has a net water inflow rate of 550 gpm (1,250 minus 700).

In the "A" pressure zone area, water demand peaked between 12 noon and 2 pm on October 20. If no power outages had occurred or if immediate backup power had been available, then the total water available for use in the firestorm area above Hiller Drive (pressure zones A7B, A9B, A11A, and A13B) could have been increased by a maximum of 1,250 gpm. The water usage calculations presented below in Sections 3.5.4 and 3.5.5 indicate that this possible increase would have been less than a 10% increase in total water available in these zones to a total of over 14,000 gpm. Therefore, it appears doubtful that such a small possible increase in available water, along with other important factors (fire fighting teams, fuel load, weather), would have had an appreciable effect on halting the spread of the fire at this time.

If the Dingee pumping plant had not been out of service due to the power outage, an additional 9,700 gpm would have been available to the B5A Dingee Zone. However, because the reservoirs serving the B5A zone were never emptied, this additional water would not have substantially affected available fire flows in the B5A zone. If the Dingee pumping had not been out of service, then additional water could have been used to pump up into the B7A Joaquin Miller pressure zone, using the Montclair pumping plant at a higher pumping rate than actually used. However, after action fire reports do not indicate problems with lack of water in the B7A pressure zone. Therefore, loss of power at the Dingee pumping plant does not appear to have had any appreciable impact on availability of water for fire suppression efforts.

If the Pinehaven pumping plant were not stopped due to the power outage, then an additional 480 gpm would have been available to pump into the B11A Pinehaven pressure zone. However, this would have depleted the B9A Thornhill pressure zone by the same amount.

Similarly, if the Hilltop pumping plant were not stopped due to the power outage, then an additional 350 gpm would have been available to pump into the B13Aa Hilltop pressure zone. However, this would have depleted the B11A Pinehaven pressure zone by the same amount.





**Table 3-10**  
**Pumping Plants Affected by Power Outages**

| Zone | Pumping Plant Name | Potential Pumping Rate          | PG&E Outage Duration                                                       | Emergency Equipment                                                                            |
|------|--------------------|---------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| A5A  | Summit South PP    | 4,200 gpm<br>(not incl. Unit 3) | 12:13 pm to<br>5:46 pm 10/20                                               | Generator at site<br>after 4:30 pm 10/20<br>Earlier access<br>restricted                       |
| A7B  | Amito PP           | 1,250 gpm                       | 11:35 am<br>(intermittent until<br>12:16 pm) to<br>about 10:00 pm<br>10/20 | 2 pumps<br>total ~1,800 gpm<br>from 3:00 pm 10/20<br>to 11:00 pm 10/21                         |
| A9B  | Strathmoor PP      | 700 gpm                         | 11:35 am<br>(intermittent until<br>11:59 am) to<br>11:42 am 10/24          | 1 pump<br>~700 gpm<br>from 12:00 noon<br>10/21 to<br>11:45 am 10/24                            |
| A11A | Gwin PP            | 750 gpm                         | 11:35 am<br>(intermittent until<br>11:57 am) to<br>10:00 am 10/24          | 1 pump<br>~400 gpm<br>ready at 10:00 am<br>10/21*, in use<br>7:00 am 10/22<br>to 2:20 am 10/24 |
| A13B | Berkeley Hills PP  | 550 gpm                         | 11:39 am to<br>6:07 pm 10/24                                               | Generator<br>available after<br>2:30 pm 10/21*<br>in use<br>10:00 pm 10/22 to<br>8:30 am 10/23 |

\* Usage times dependent upon availability of water in lower zone

| Zone  | Pumping Plant Name | Potential Pumping Rate                     | PG&E Outage Duration                                        | Emergency Equipment                                                                                                                                                                                                                              |
|-------|--------------------|--------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B5A   | Dingee PP          | 9,700 gpm (incl.<br>Summit South Unit 3)   | 12:13 pm until<br>5:46 pm 10/20                             | Generator at site<br>after 4:30 pm 10/20<br>Earlier access<br>restricted by fire                                                                                                                                                                 |
| B11A  | Pinehaven PP       | 480 gpm<br>(per 1990<br>pump test<br>data) | Between 1:33 pm<br>and 2:37 pm 10/20<br>until 3:45 am 10/24 | 1 Pump ~150 gpm<br>(limited by<br>available water)<br>1:00 am 10/21 until<br>12:50 pm 10/21.<br>Generator 75 kW<br>at site 10:00 am<br>10/21 on with 1<br>pump at 12:50 pm<br>10/21, 2 pumps<br>at 3:45 am 10/22,<br>1 pump at 9:00 am<br>10/22. |
| B13Aa | Hilltop PP         | 350 gpm<br>(per 1990<br>pump test<br>data) | Between 1:33 pm<br>and 2:47 pm<br>until 6:40 pm 10/25       | Generator at site<br>2:30 pm 10/21.<br>Generator in use<br>with 1 pump 6:45<br>am 10/22 to<br>7:10 am 10/23                                                                                                                                      |





In summary, the power outages which affected these eight pumping plants did not substantially reduce the amounts of water available for fire suppression during the times of peak demand. If the power failures had not occurred or if immediate emergency power had been available, the additional water supplies which would have been available in pressure zones where water limitations occurred during peak demand times would have been less than ten percent. Therefore, the power outages did not contribute substantially to the combination of conditions (primarily extreme water demand) which resulted in the temporary emptying of ten reservoirs.

#### **3.5.4 Water Usage in Each Pressure Zone**

This section summarizes estimates of water usage during the firestorm emergency in each of the 11 fire-area pressure zones. For each pressure zone, a two-part figure is presented. The top figure shows total hourly water usage in the zone for the seven one-hour periods between 11:00 am and 5:00 pm on October 20. Each one-hour bar shows water usage for the one-hour period following the stated time. For example, the 11:00 am bar shows water usage between 11:00 am and 12:00 noon. The top figures also show the reservoir water status (percentage of full) and the cumulative spread of the fire through the pressure zone over this same time interval (percentage of the zone). The data points for reservoir percentage full and fire spread in the zone are instantaneous estimates on the hours shown.

For each pressure zone, the bottom figure shows total water usage in the zone for the 31 one-hour periods between 8:00 am on October 20 and 2:00 pm on October 21. The bottom figures also show the reservoir level (in millions of gallons) during this time period. For each pressure zone, a map is presented which shows the spread of the firestorm through the pressure zone (based on the California Office Of Emergency Services fire spread map, Figure 2-1)

As discussed in Section 3.5.2, water availability in a pressure zone depends on several factors in addition to there being water in the source reservoir. For example, even if the source reservoir for a particular zone is empty at a given time, there can still be water supplied to the zone by pumping from another zone or from pressure regulators drawing from another supply reservoir.

For each pressure zone, the text accompanying the figures summarizes key events occurring in the zone, including: comments on the fire spread in the zone, analyses of water usages at various times, the chronology of key events such as reservoirs emptying, the status of emergency equipment, and other pertinent information. For each pressure zone, the peak fire flow rates and durations are summarized and compared to the current fire flow standard for new residential construction in the hills area (1,500 gpm for two hours).

The discussion of water in each pressure zone emphasizes total water usage because fire flows are the best single indicator of fire-suppression capability. Other factors, including water storage, pumping plant capacities, and the design criteria of the distribution system in each pressure zone were discussed previously in this chapter. The





water flow estimates presented below for each pressure zones represent total water flows provided by the zones, including fire flows, losses from broken services, and other uses. As discussed in Section 3.5.2, approximately one-quarter to one-third of these totals may represent losses from broken services. The remaining two-thirds to three-quarters of total water supplied in the zones is predominantly fire flows used by firefighters in the zone.

### **Summit Pressure Zone A5A**

As shown in Figure 3-9, water use in the Summit Pressure Zone A5A on October 20 was about 1000 gpm from 8:00 am until 2:00 pm. This water usage rate reflects normal residential uses. Water use increased rapidly to between 4,000 and 6,000 gpm from 2:00 pm until 5:00 pm as firefighting efforts expanded in this zone. Between 5:00 pm and 6:00 pm, water use was about 2,000 gpm. From 6:00 pm through 12 midnight, water use ranged about 4,000 gpm to 5,000 gpm. For the subsequent 15 hours, water use averaged about 3,000 gpm.

The Summit South reservoir was emptied on two occasions during this time period. However, water flow in the zone was still available on these occasions, from pumping plants drawing from other zones. The main pumping plant for the A5A zone in the area of the firestorm is the Summit South pumping plant. This pumping plant was not available from 12:16 pm until 5:46 pm, due to a PG&E power outage. When the Summit South reservoir was nearing empty at 5:00 pm October 20, the Summit East pumping plant was started, and provided a flow of about 3,000 gpm. At 5:46 pm, PG&E restored power to the Summit South pumping plant, and that pumping plant provided a flow of about 4,000 gpm.

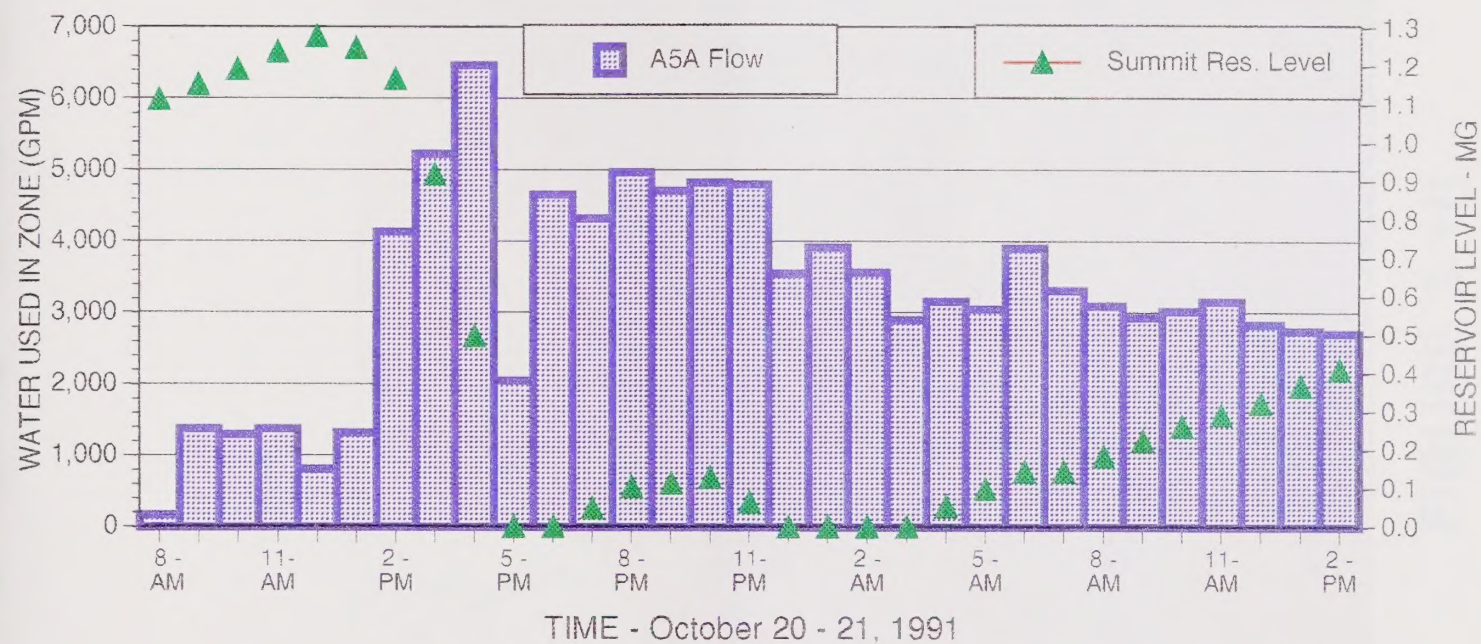
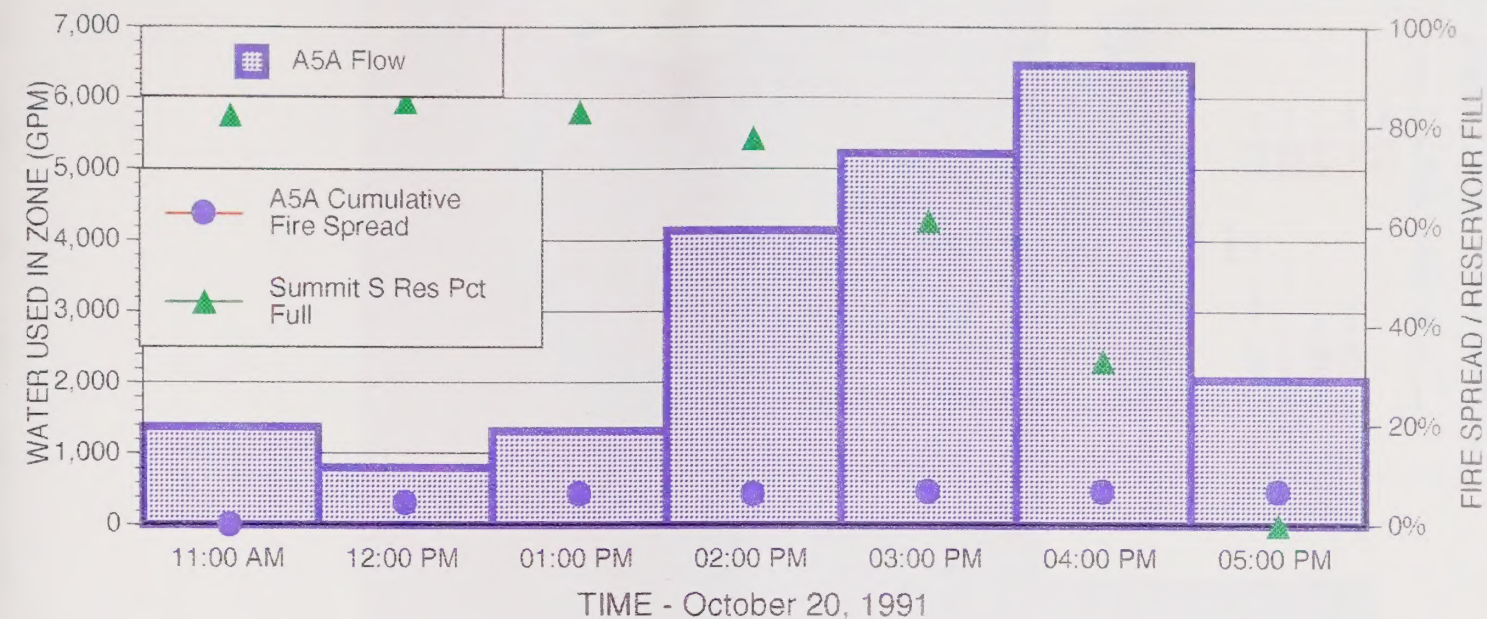
Two portable pumps to pump water out of Summit Pressure zone A5A into the Amito A7B pressure zone began operations at about 3:00 pm on October 20, drawing a total of about 1,800 gpm.

The "normal" water usage from 11:00 am to almost 2:00 pm suggests that fire fighting activities did not begin in force in the A5A Summit pressure zone until about 2:00 pm. The water use rate between 4,000 gpm and 6,000 gpm thereafter, along with other factors (mobilized fire fighting teams, reduced winds, etc.) combined to help stop the spread of the fire in this pressure zone by about 3:00 pm on October 20. The fire spread chronology in the Summit zone is shown in Figure 3-10.

For the 10-hour period on October 20 beginning at 2:00 pm, total water provided in the Summit pressure zone averaged above 4,000 gpm. These flows substantially exceeded the current hills area fire flow standard of 1,500 gpm for two hours in both flow rate and flow duration.







### A5A SUMMIT PRESSURE ZONE

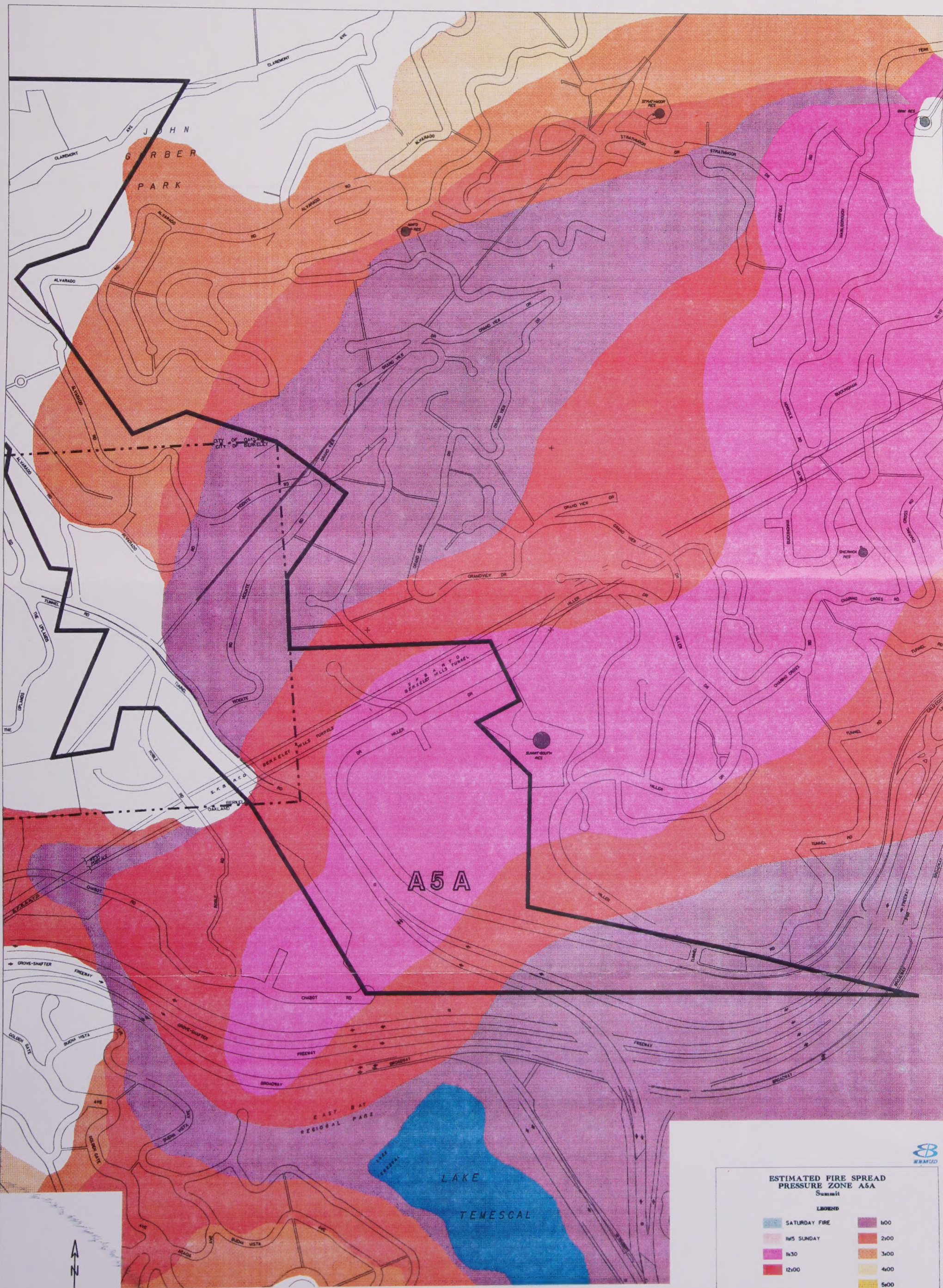
Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

Figure 3-9





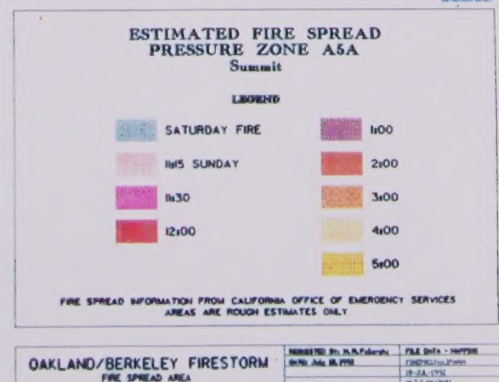




SCALE: 1" = 500'

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FIGURE 3-10







### **Amito Pressure Zone A7B**

As shown in Figure 3-11, water use in the Amito Pressure Zone A7B on October 20 averaged about 300 gpm from 8:00 am until 11:00 am. Then, water use increased rapidly to between 4,300 and 6,700 gpm from 12 noon until 2:00 pm. The Amito and Sherwick reservoirs were emptied at approximately 2:30 pm. Two portable pumps began operations at about 3:00 pm, drawing a total of about 1,800 gpm of water from the Summit South reservoir and pumping it into the A7B Amito pressure zone.

PG&E power was lost to the Amito pumping plant by 12:16 pm (intermittently from 11:35 am), and restored at about 10:00 pm on October 20.

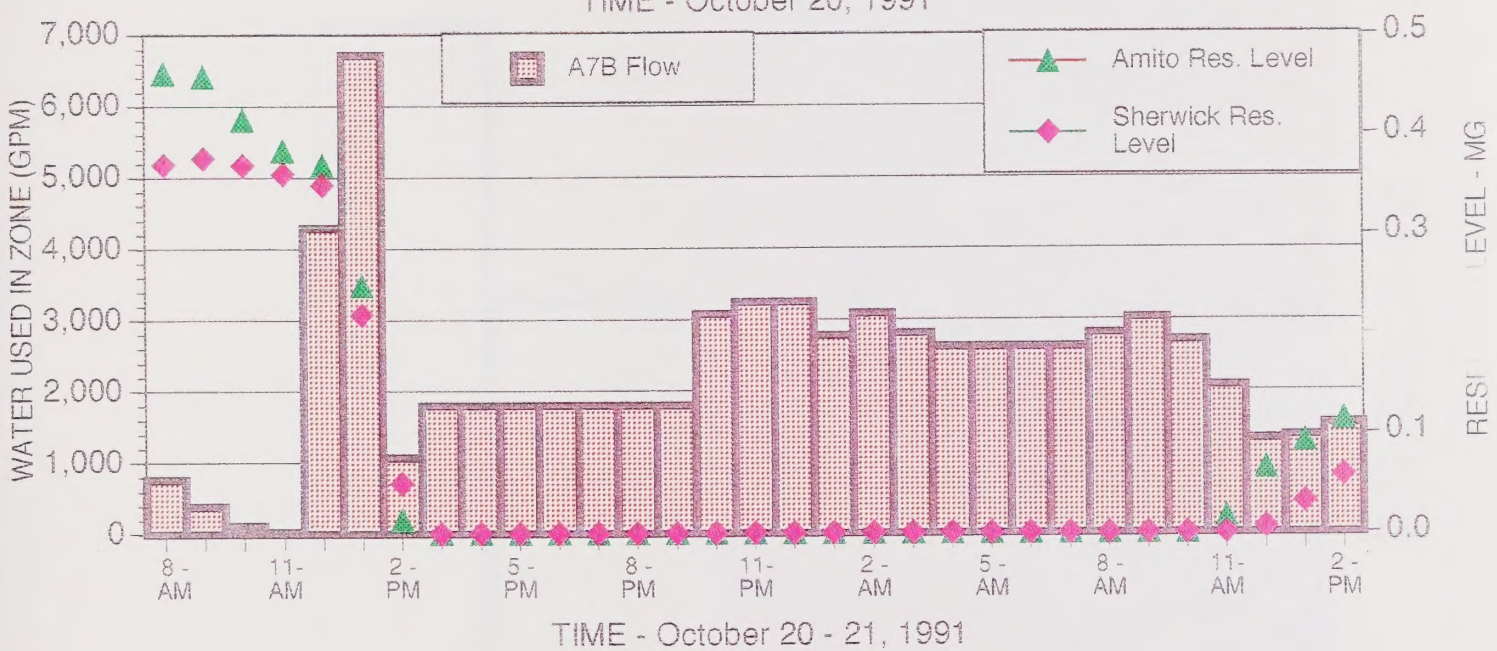
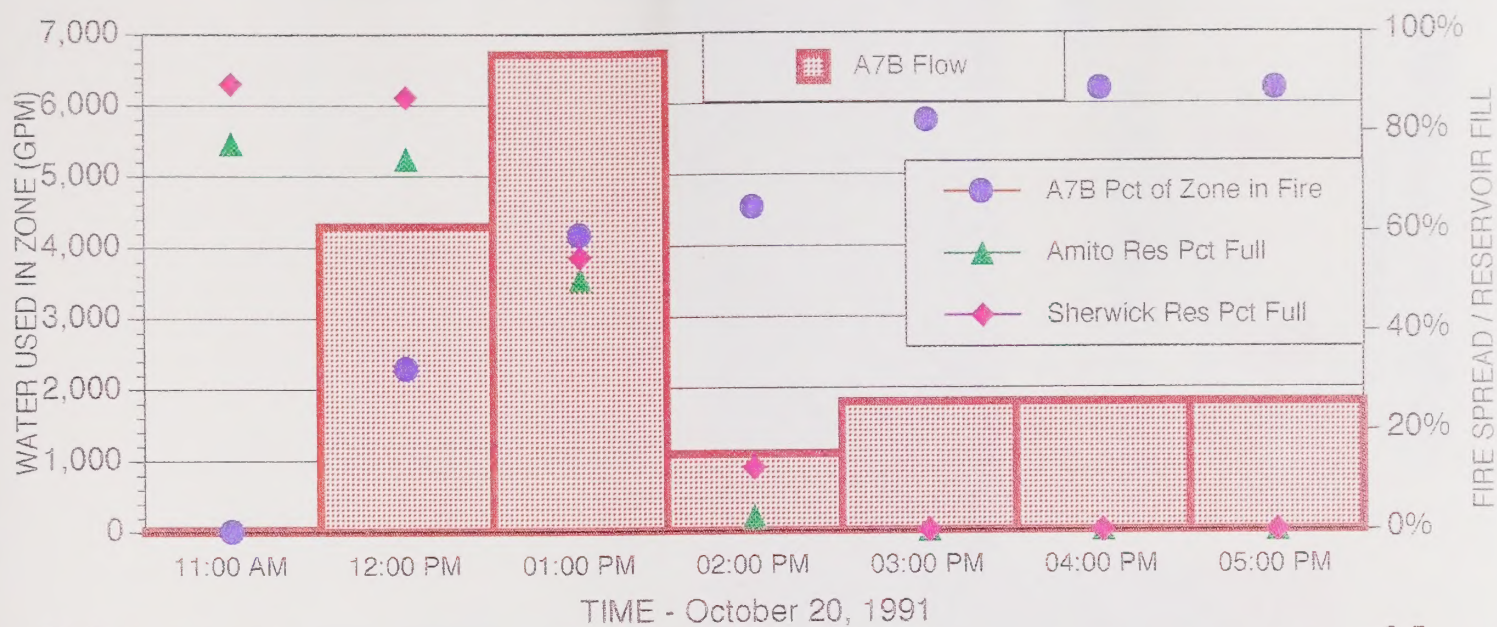
A portable pump began drawing about 700 gpm from the Amito pressure zone beginning at 12 noon October 21 and pumping it into the A9B Strathmoor pressure zone.

The water use rate of about 5,000 gpm from 12 noon until 2:00 pm, combined with other factors (fire fighting resources, fuel load, weather), was apparently insufficient to stop the continued spread of the fire during this time period. The water use rate of about 1,800 gpm from 3:00 pm onwards, for many hours, helped limit the spread of the fire in this pressure zone. The fire spread chronology in the Amito zone is shown in Figure 3-12.

For the two-hour period on October 20 beginning at 12:00 noon, total water provided in the Amito pressure zone averaged more than 4,000 gpm. This flow rate provided by the Amito zone substantially exceeded the current hills area fire flow standard of 1,500 gpm.







### A7B AMITO PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

Figure 3-11







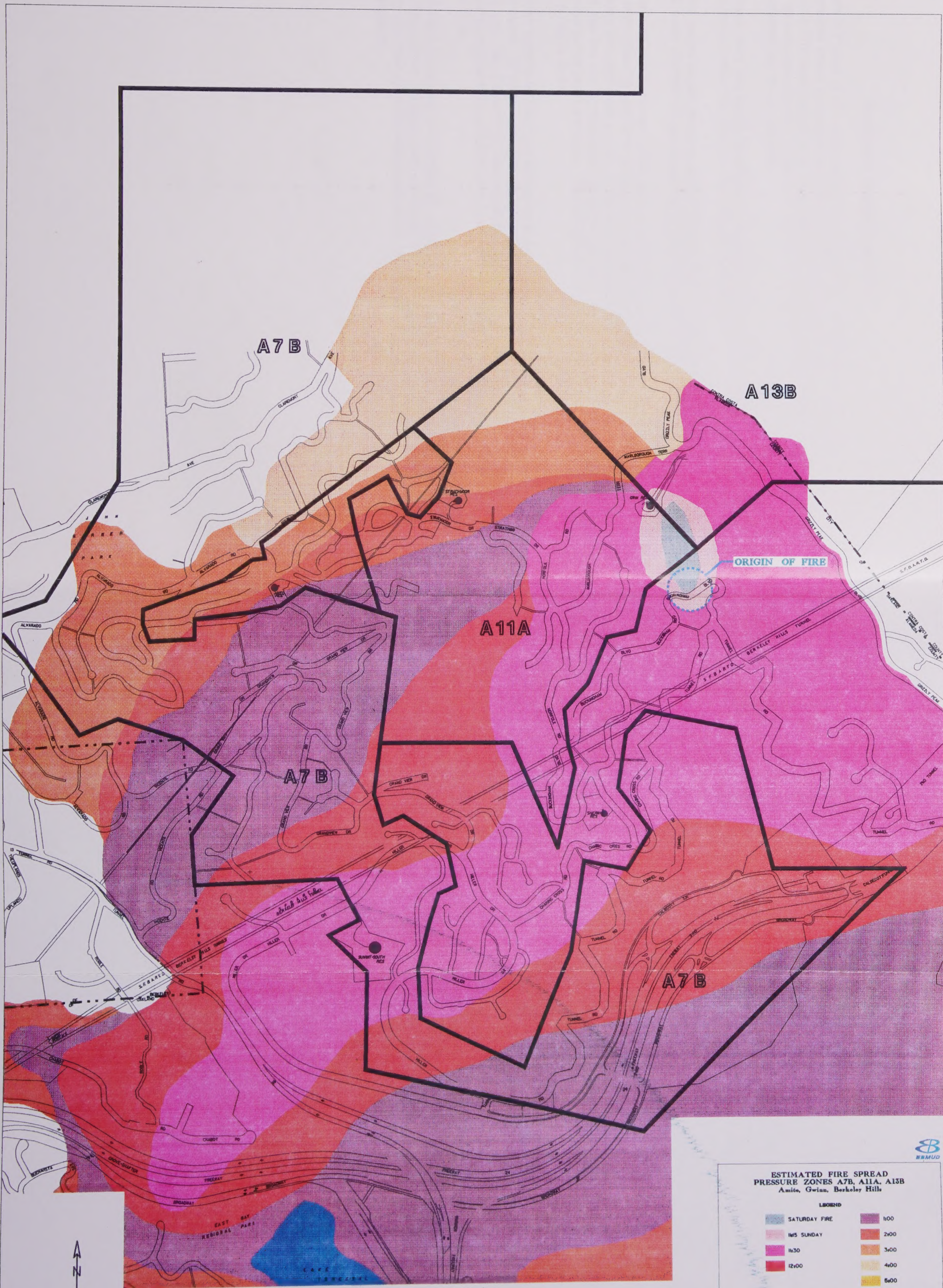


FIGURE 3-12

SCALE: 1" = 700'

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OAKLAND/BERKELEY FIRESTORM  
 FIRE SPREAD AREA





### Strathmoor Pressure Zone A9B

As shown in Figure 3-13, water use in the Strathmoor Pressure Zone A9B on October 20 averaged about 50 gpm from 8:00 am until 11:00 am. Then, water use increased to about 700 gpm for the next hour (reflecting beginning of fire fighting operations), to an average of about 3,000 gpm for the next three hours. The Strathmoor reservoir was emptied by about 3:00 pm.

PG&E power was lost to the Strathmoor pumping plant by 11:59 am (intermittently from 11:35 am) on October 20. Power was restored on October 24.

A portable pump began drawing about 700 gpm from the Amito pressure zone beginning at 12 noon October 21 and pumping it into the A9B Strathmoor pressure zone.

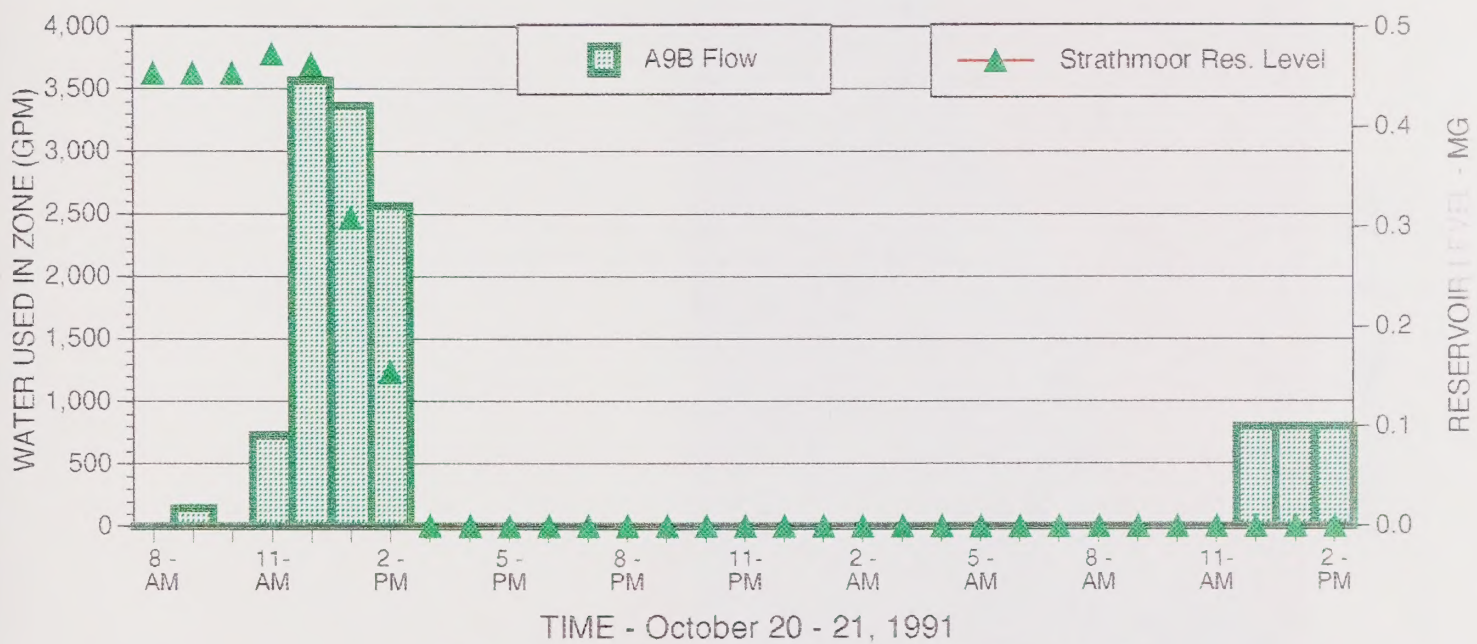
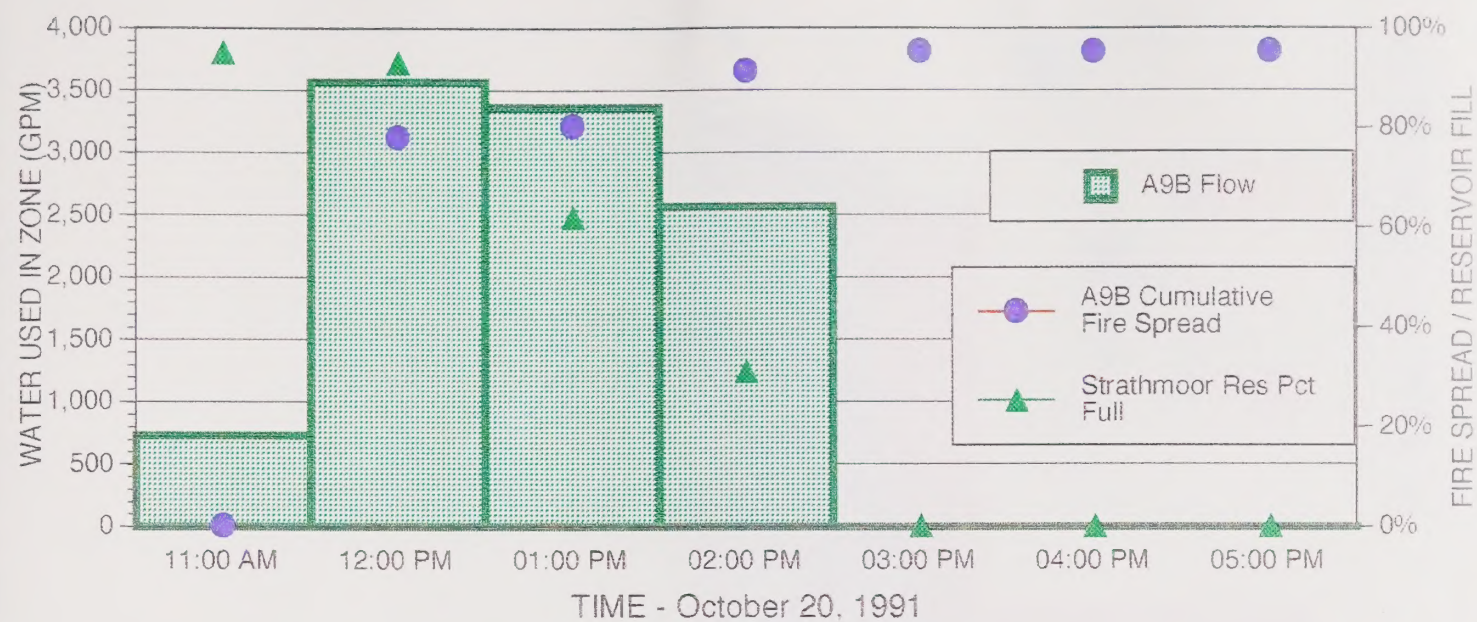
The water use rate between 2,500 gpm and 3,500 gpm from 12 noon until 3:00 pm, combined with other factors (fire fighting teams, fuel load, weather) were apparently insufficient to stop the continued spread of the fire, as reflected by the continued increase of the spread of the fire during that time. By about 3:00 pm on October 20, the fire had spread through the entire pressure zone. The fire spread chronology in the Strathmoor zone is shown in Figure 3-14.

After action reports by fire fighting teams at Bay Forest Drive show that they were out of water by about 12 noon, even though there was water in the Strathmoor reservoir until about 3:00 pm. Bay Forest is at the end of the A9B zone, and reductions of water to the hydrants at this location are probably due to overdrafting at other hydrants nearer the reservoir at this time.

For the three-hour period on October 20, beginning at 12:00 noon, total water provided in the Strathmoor pressure zone averaged more than 2,500 gpm. These flows exceeded the current hills area fire flow standard of 1,500 gpm for two hours in both flow rate and flow duration.







### A9B STRATHMOOR PRESSURE ZONE

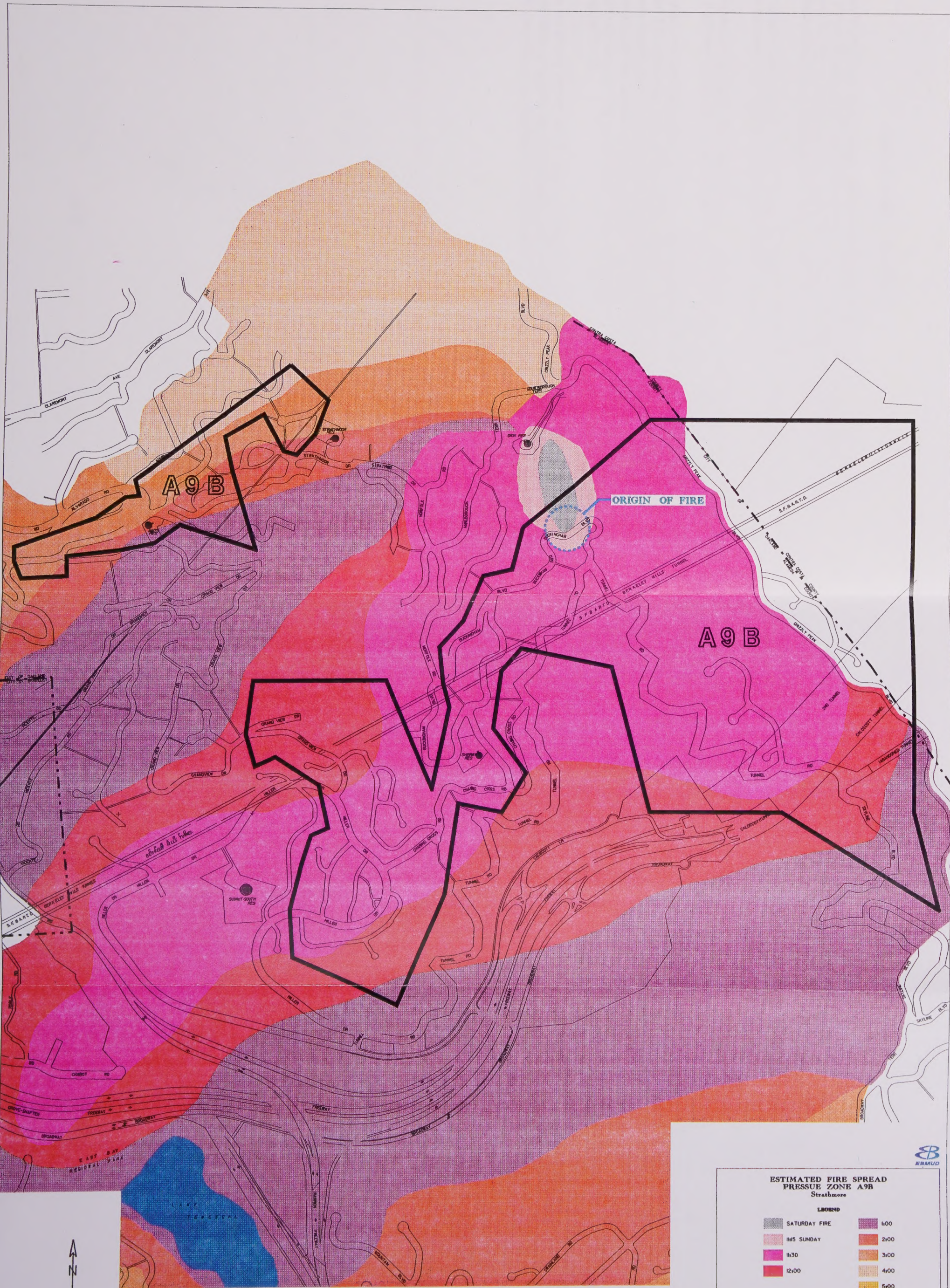
Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

Figure 3-13





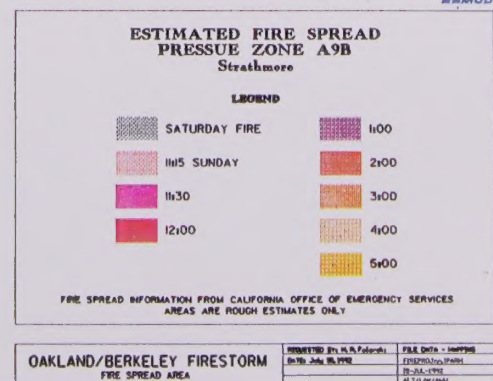




SCALE: 1" = 700'

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FIGURE 3-14







### Gwin Pressure Zone A11A

As shown in Figure 3-15, water use in the Gwin Pressure Zone A11A on October 20 averaged about 75 gpm from 8:00 am until 11:00 am. Then, water use increased about 300 gpm for the next hour, to an average of about 2,800 gpm for the next two hours. The Gwin reservoir was emptied by about 2:00 pm on October 20.

PG&E power was lost to the Gwin pumping plant by 11:57 am (intermittently from 11:35 am) on October 20. Power was restored on October 24.

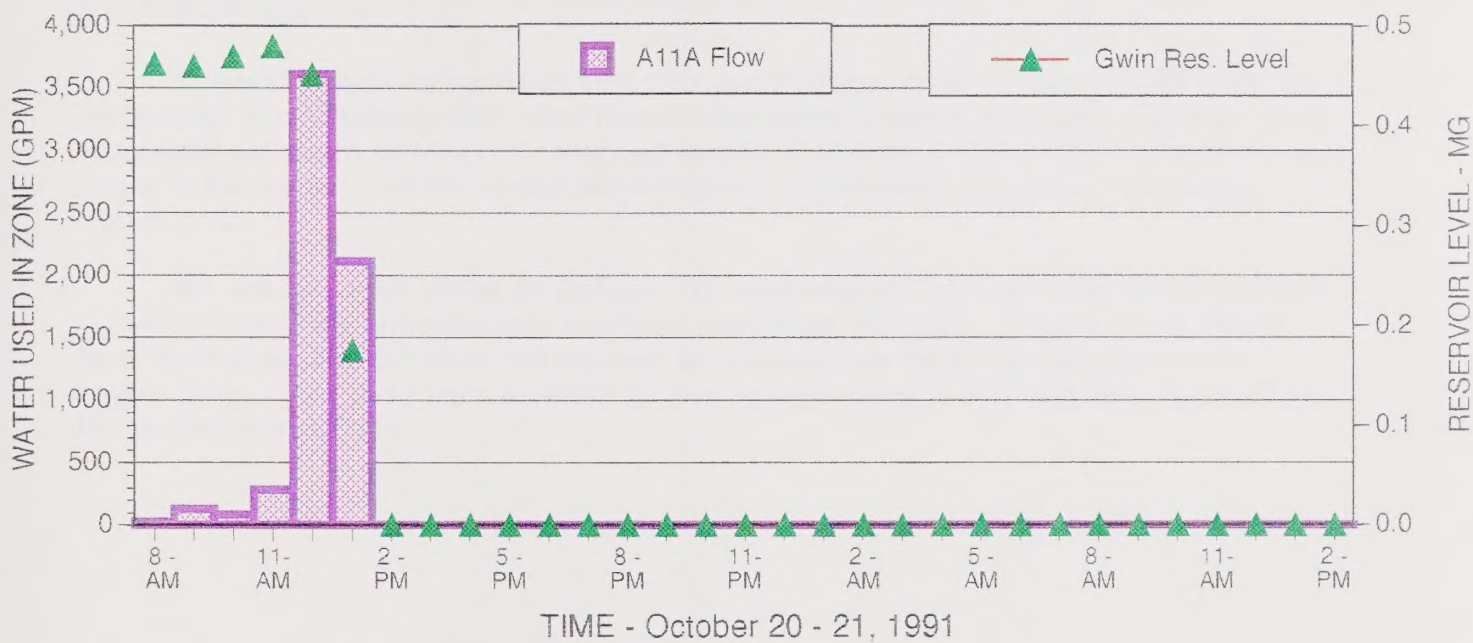
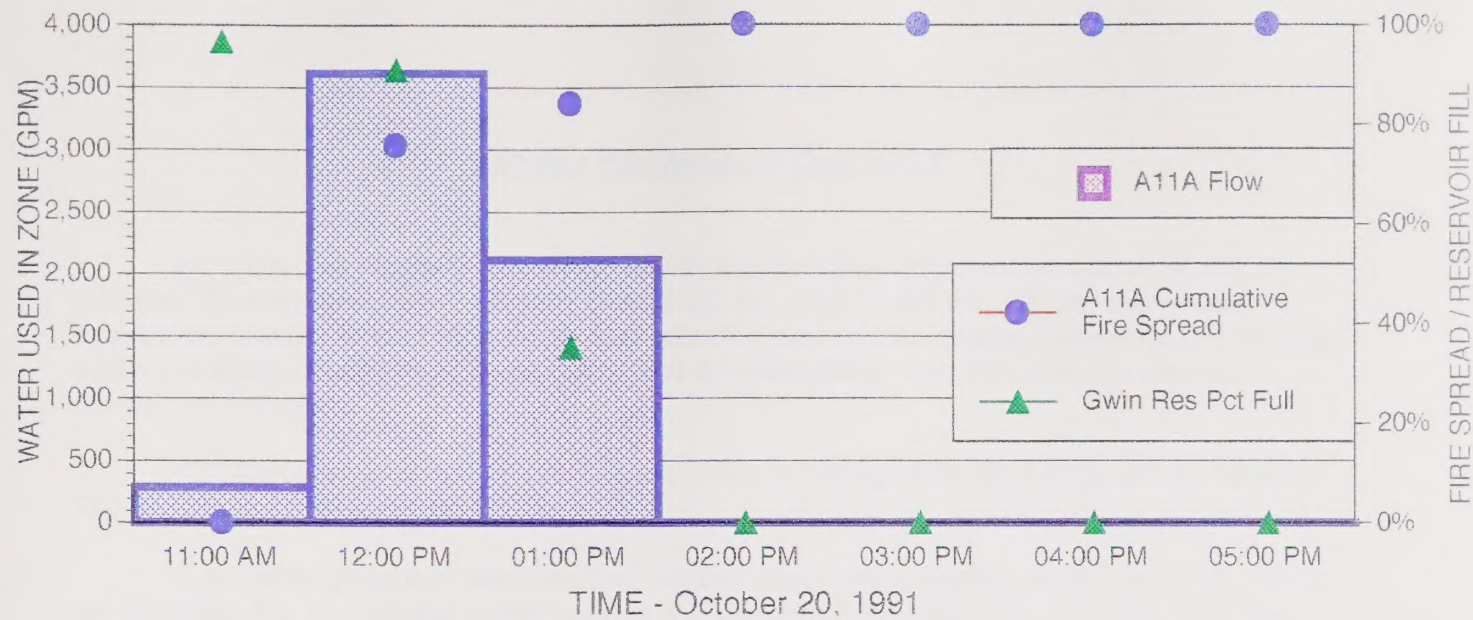
A portable pump began drawing about 400 gpm from the Strathmoor pressure zone beginning at 7:00 am October 22 and pumping it into the A11A Gwin pressure zone.

The water use rate between 2,000 gpm and 3,500 gpm from 12 noon until 2:00 pm on October 20, combined with other factors (fire fighting teams, fuel load, weather) were apparently insufficient to stop the continued spread of the fire, as reflected by the continued increase of the spread of the fire during that time. By 3:00 pm on October 20, the fire had spread through the entire zone. The fire spread chronology in the Gwin zone is shown in Figure 3-12.

For the two-hour period on October 20, beginning at 12:00 noon, total water provided in the Gwin pressure zone averaged about 2,800 gpm. These flows exceeded the current hill area fire flow standard of 1,500 gpm for two hours.







### A11A GWIN PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

Figure 3-15





### Berkeley Hills Pressure Zone A13B

As shown in Figure 3-16, water use in the Berkeley Hills Pressure zone A13B on October 20 averaged about 10 gpm from 8:00 am until 11:00 am. Then, water use increased, ranging from 150 gpm to 500 gpm for the next six hours, reflecting fire fighting activities along Grizzly Peak Boulevard. The Berkeley Hills reservoir was not emptied during the firestorm.

PG&E power was lost to the Berkeley Hills pumping plant by 11:39 am on October 20. Power was restored on October 24.

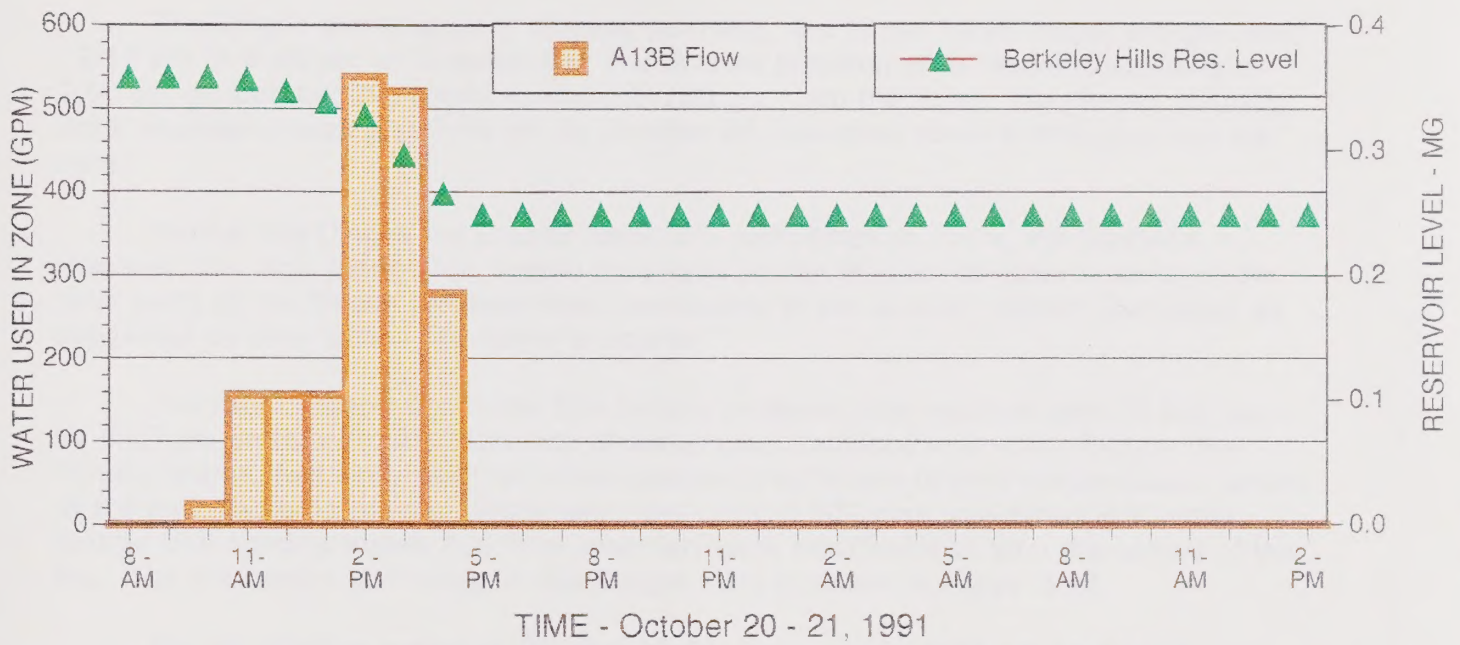
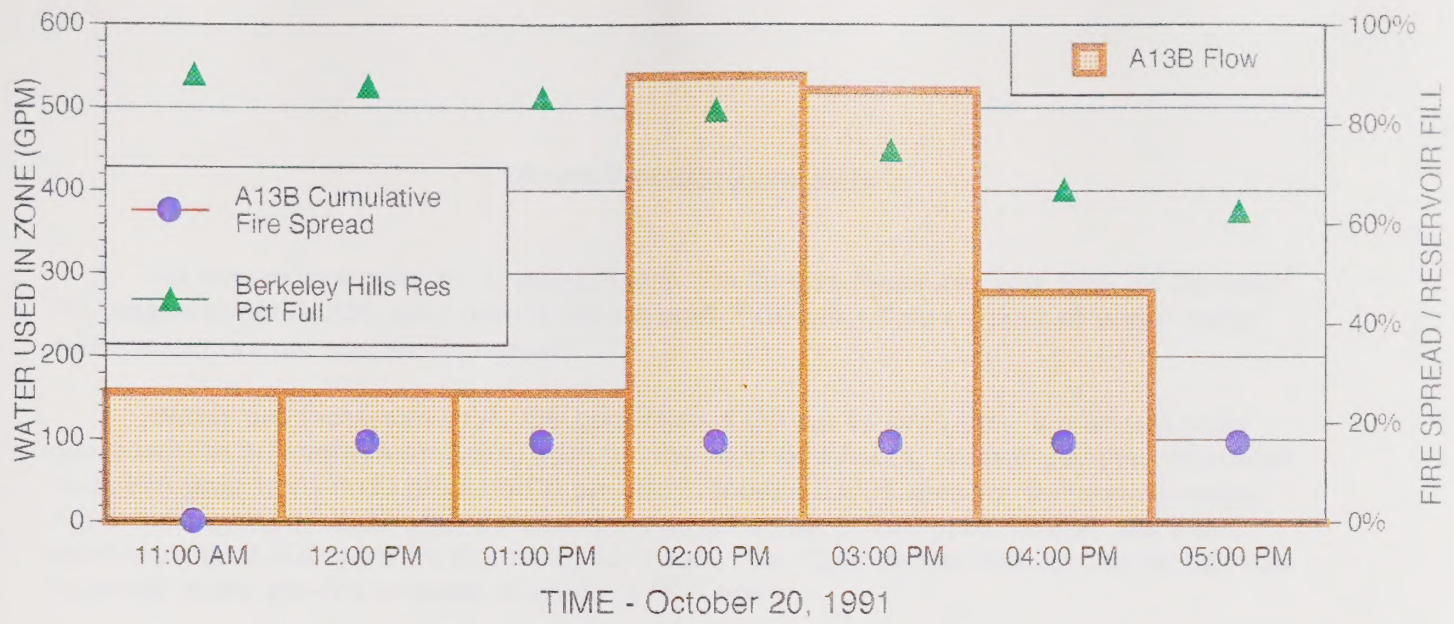
A portable generator was used at the Berkeley Hills pumping plant beginning 10:00 pm October 22, to increase water level in the Berkeley Hills reservoir, drawing from the A11A Gwin reservoir.

The water use rate between 150 gpm and 500 gpm from 11:00 am until 4:00 pm on October 20 combined with other factors (fire fighting teams, fuel load, weather) were apparently sufficient to stop the continued spread of the fire and to prevent loss of the one house in this zone. The fire spread chronology in the Berkeley Hills zone is shown in Figure 3-12.

For the two-hour period on October 20, beginning at 2:00 pm, total water provided in the Berkeley Hills pressure zone averaged more than 500 gpm. Greater flows would have been available, but were not required to suppress the fire in this pressure zone. Higher flows could have been provided by this pressure zone if they had been required for fire suppression efforts.







### A13B BERKELEY HILLS PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

**FIGURE 3-16**





### Dingee Pressure Zone B5A

As shown in Figure 3-17, water use in the Dingee Pressure Zone B5A on October 20 ranged about 2,000 gpm from 8:00 am until 1:00 pm. This amount of water usage reflects the normal residential usages.

Water use increased to 8,000 gpm from 1:00 pm to 2:00 pm. Water use then decreased to an average of 2,500 gpm for the next two hours. Water use then increased to 6,500 gpm from 4:00 pm to 5:00 pm, then about 12,000 gpm for the next 9 hours. From 2:00 am until 8:00 am, water use averaged about 9,000 gpm. Water use then decreased to 6,000 gpm for the next four hours. By 12 noon October 21, water use had returned to the pre-fire average of about 3,000 gpm.

The Dingee pumping plant stopped pumping, due to the PG&E power outage, from 12:16 pm to 5:46 pm on October 20. The Estates pumping plant resumed pumping at 2:00 pm on October 20, providing about 3,700 gpm into the zone. The Dingee pumping plant resumed pumping at 5:46 pm on October 20, providing about 6,500 gpm into the zone.

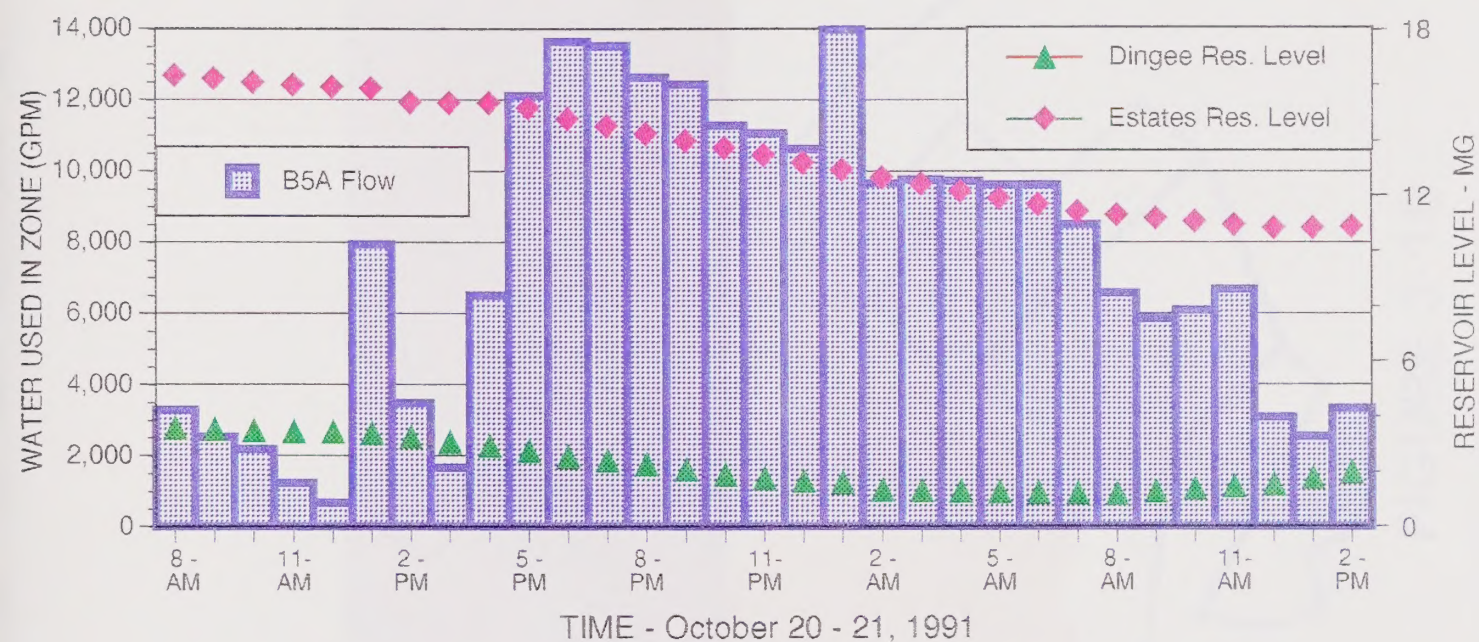
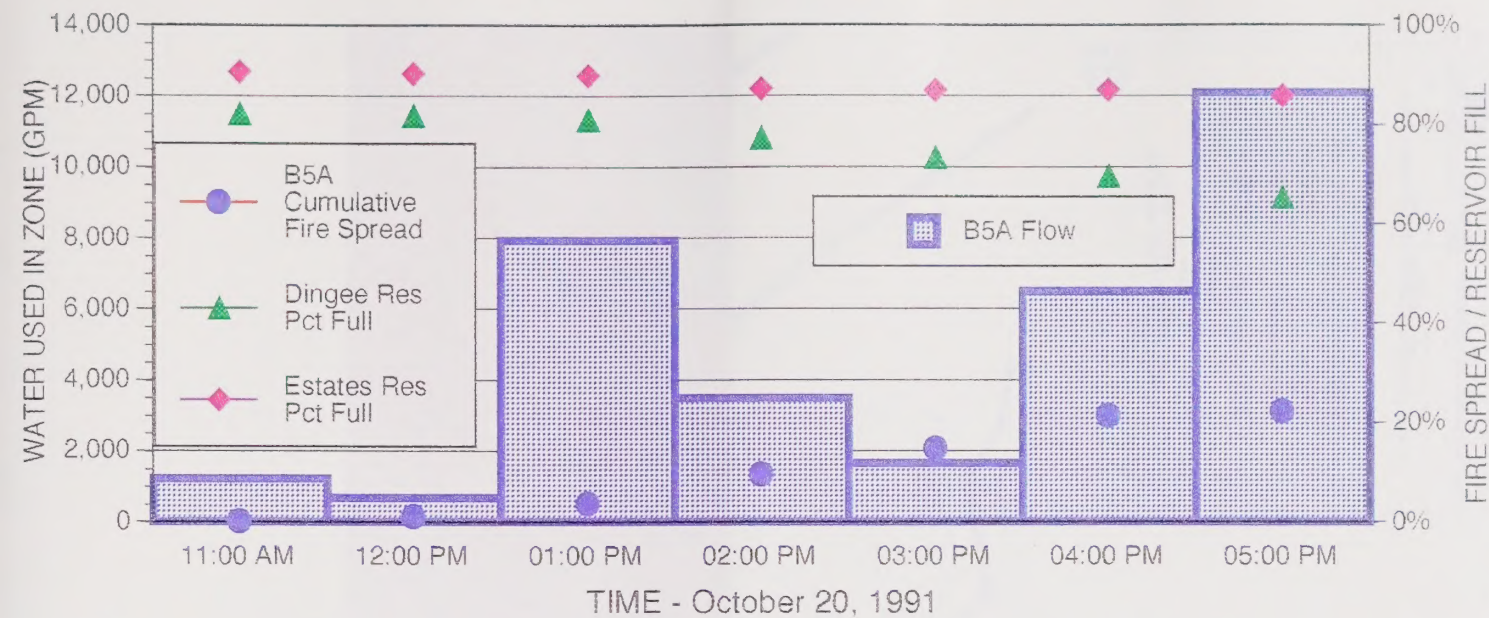
Neither the Dingee nor Estates reservoirs were emptied during the firestorm. However, the pipe distribution system may have limited the use of water in some of the older parts of the Dingee pressure zone, particularly in the Acacia - Golden Gate area, as suggested by after action fire fighter's reports.<sup>20</sup>

The rate of water use in the B5A Dingee pressure zone reached over 12,000 gpm by 5:00 pm on October 20. This rate of water use, combined with other factors (fire fighting teams, fuel load, weather) were apparently sufficient to stop the continued spread of the fire. Earlier in the day, water use rates up to 8,000 gpm, combined with other factors (fire fighting teams, fuel load, weather) were insufficient to stop the spread of the fire. The fire spread chronology in the Dingee zone is shown in Figure 3-18.

For the 20-hour period on October 20-21, beginning at 4:00 pm, total water provided in the Dingee pressure zone averaged more than 6,000 gpm. These flows substantially exceeded the current hills area fire flow standard of 1,500 gpm for two hours in both flow rate and flow duration.







### B5A DINGEE PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

**FIGURE 3-17**









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FIGURE 3-18

**ESTIMATED FIRE SPREAD PRESSURE ZONE B5A**

**Dingo**

| LEGEND        |      |
|---------------|------|
| SATURDAY FIRE | 1100 |
| 11H5 SUNDAY   | 2100 |
| 11H30         | 3100 |
| 12100         | 4100 |
|               | 5100 |

FIRE SPREAD INFORMATION FROM CALIFORNIA OFFICE OF EMERGENCY SERVICES  
AREAS ARE ROUGH ESTIMATES ONLY

OAKLAND/BERKELEY FIRESTORM  
FIRE SPREAD AREA

REVISION: 01-15-1995  
DATE: July 15, 1995  
BY: JAL-1995  
BY: JAL-1995

FILE: 01-15-1995  
PROJECT: 01-15-1995  
BY: JAL-1995





### Broadway Terrace Regulator Pressure Zone B4Aa

As shown in Figure 3-19, water use in the Broadway Terrace Regulator Pressure Zone B4Aa on October 20 averaged about 50 gpm before the fire began. This water usage reflects normal residential use. Between 11:00 am and 4:00 pm water use increased to about 2,000 gpm, reflecting increasing use for fire suppression efforts. As discussed below, water usage estimates in the Broadway Terrace Regulator Pressure Zone are rough, because there are no flow meters on the regulators. The estimated water usage of 2,000 gpm for 17 hours beginning at 4:00 pm on October 20 is based on the estimated flow capacity of the two regulators which feed this zone.

The B4Aa Broadway Terrace Regulator Pressure Zone has no reservoir within the zone - instead, it draws its water through two pressure regulators, one at each end of the zone. The Buena Vista regulator is located in the northeast corner of the zone, drawing water from the B5A zone along Buena Vista. The Broadway Terrace regulator is located in the southeast corner of the zone, drawing its water from the B5A zone along Broadway Terrace.

As previously mentioned, there are no OP/NET data acquisition devices to record the amount of flow through these two regulators into the B4Aa Broadway Terrace pressure zone. Data recorders at these two regulators had been taken out of service prior to the firestorm, reportedly to limit the cost of data collection.<sup>21</sup> Therefore, the amount of water that flowed into the B4Aa zone can only be estimated based upon operational characteristics of the water distribution system, considering the competing demands for water in the B5A zone. According to District operations personnel, it is possible that about 1,000 gpm could have flowed through each of the two regulators.<sup>22</sup>

District personnel opened and closed zone gate valves during the afternoon of October 20, upon requests from fire-fighting personnel. At 9:20 pm October 20, zone gates were opened at Harbord and Mandalay (B5A Dingee zone) to increase flows into the B4Aa Broadway Terrace zone. The Broadway Terrace pressure regulator was plugged by a slug of sand at that time. By 2:00 am October 21, the Broadway Terrace Regulator was repaired and back in service. (Note that the data in Figure 3-26 does not directly reflect the amount of water passed from B5A to B4Aa due to open zone gates, but does assume that the Broadway Terrace regulator was in service throughout. The result of this assumption is that the split of water between B4Aa and B5A is uncertain, but the total amount remains constant). Thus, the water use data shown in Figure 3-21 should be viewed with consideration of the large uncertainties involved.

Even considering these uncertainties, reliable data from fire department after action reports<sup>20</sup> that confirm the use of water within the B4Aa zone at various times. For example, Acting Lt. L. White of the Oakland Fire Department reported that:

"We assisted Lt. G. Berry at Buena Vista Place and Lt. R. Padialla on Buena Vista Avenue fighting structure and brush fires for approximately 6 hours. We saved all the structures on Buena Vista Place and below the curve on Buena Vista Avenue. During the time, we lost water a few times."





It is most likely that G. Berry was drafting water from the fire hydrant at the corner of Buena Vista Place and Buena Vista Avenue. This hydrant is the first hydrant in the B4Aa zone after the Buena Vista regulator. Lt. White's comment that water was lost a few times reflects the continual drafting going on at other hydrants in the B5A zone, and that such drafting changes the flows going to B4Aa.

Due to the limitations of the piping distribution system in B4Aa, and the fact that the first hydrant in the zone in this area was probably continually drafting water during the spread of the fire front, it is not surprising that other fire fighters reported lack of water, further away from the regulator. For example,<sup>20</sup> Captain F. Baleria reported that:

"... connected to hydrants at Country Club and Beechwood, and Country Club and Bowling, and had barely enough water to supply one 1 1/2" hose line."

Likely at about the same time, in another after action report,<sup>20</sup> fire fighter R. Banks reported that:

"... After about 45 minutes, we got our hydrant pressure back so we set up to make a stand just above Country Club. With the added water and the diminishing winds, we were able to stop the fire's progress in that area."

Similarly, in another after action report<sup>20</sup>, Captain G. A. Flom reported that:

"... laid a hose from the hydrant [at Rockridge Blvd. South]... ...crews extinguished an apartment house on the east side of Margarido ... when the water failed. ... at this time, crews were in full retreat. ... restored water pressure ... enabled us to set up portable hydrants on Margarido and attack and suppress the house fire, saving the structure near the original hydrant."

These reports clearly suggest that there was intermittent supply of water in the B4Aa zone. The duration and extent of these intermittent shortages are not precisely known, but suggest the following:

- Continual use in the B5A zone caused some fluctuations in the supply through the Buena Vista regulator, but such fluctuations were of short enough duration, and limited extent, such that the first hydrant after the Buena Vista regulator, at Buena Vista Place, flowed enough water to allow fire fighters to successfully save every structure near that hydrant.
- Essentially continual use of water through this first hydrant at Buena Vista Place significantly reduced the amount of water available to flow to the rest of the hydrants in the B4Aa zone. The hydrants at Rockridge Boulevard South and Country Club/Acacia are at the furthest distant points from the Buena Vista and Broadway Terrace regulators; therefore, it is not surprising that these hydrants were in limited supply.

The design of the water distribution system in the B4Aa pressure zone is further





described in Section 3.2 of this report. But some key points are noted here:

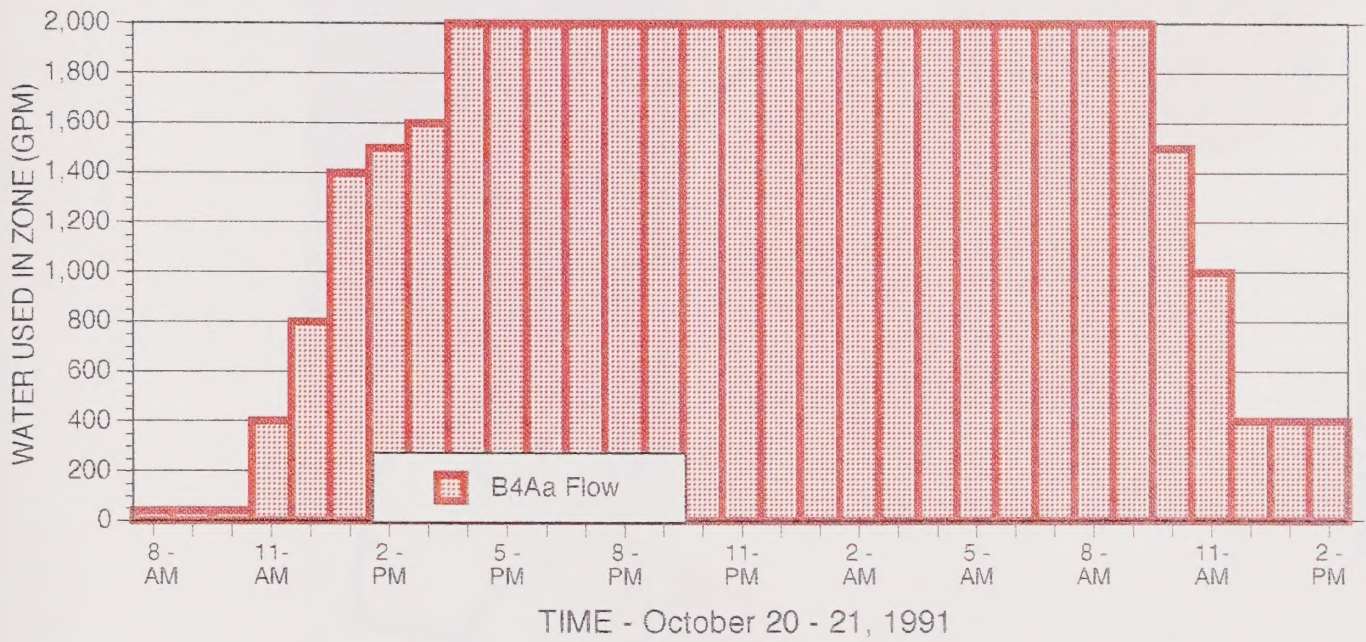
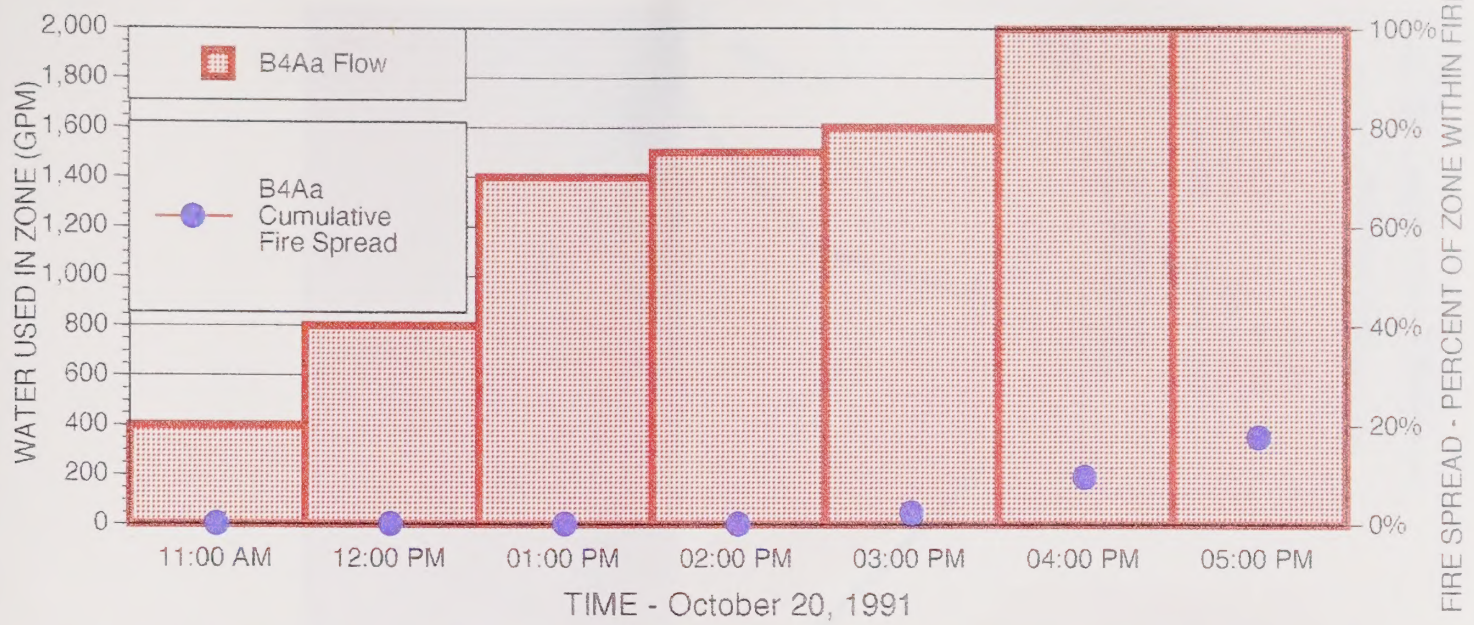
- Multiple fires were being fought in the B4Aa pressure zone at the same time, located at distances over 0.5 miles apart.
- Firefighters can easily use over 1,000 gpm using modern equipment to fight a single area fire.
- By supplying water to save the structures at Buena Vista Place, the B4Aa distribution system could not simultaneously deliver adequate flows to all other fire fighting teams within the B4Aa zone.

The fire spread chronology in the Broadway Terrace zone is shown in Figure 3-20.

Despite water limitations in some parts of this zone at some times, water was provided continuously to this zone. For the 21-hour period beginning on October 20 at 2:00 pm, total water provided in the Broadway Terrace pressure zone averaged more than 1,500 gpm. Therefore, this zone provided flows at or above the current hills area fire flow rate standard of 1,500 gpm for durations which substantially exceeded the duration standard of two hours.







### B4Aa BROADWAY TERRACE PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

**FIGURE 3-19**









SCALE: 1" = 400'

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**FIGURE 3-20**

**OAKLAND/BERKELEY FIRESTORM  
FIRE SPREAD AREA**

PREPARED BY: J. S. FALCONE  
DATE: JULY 1978  
FIRE SPREAD AREA  
JULY 1978





### Joaquin Miller Pressure Zone B7A

As shown in Figure 3-21, water use in the Joaquin Miller Pressure Zone B7A on October 20 averaged about 500 gpm from 8:00 am until 11:00 am. This amount of water usage reflects normal residential uses.

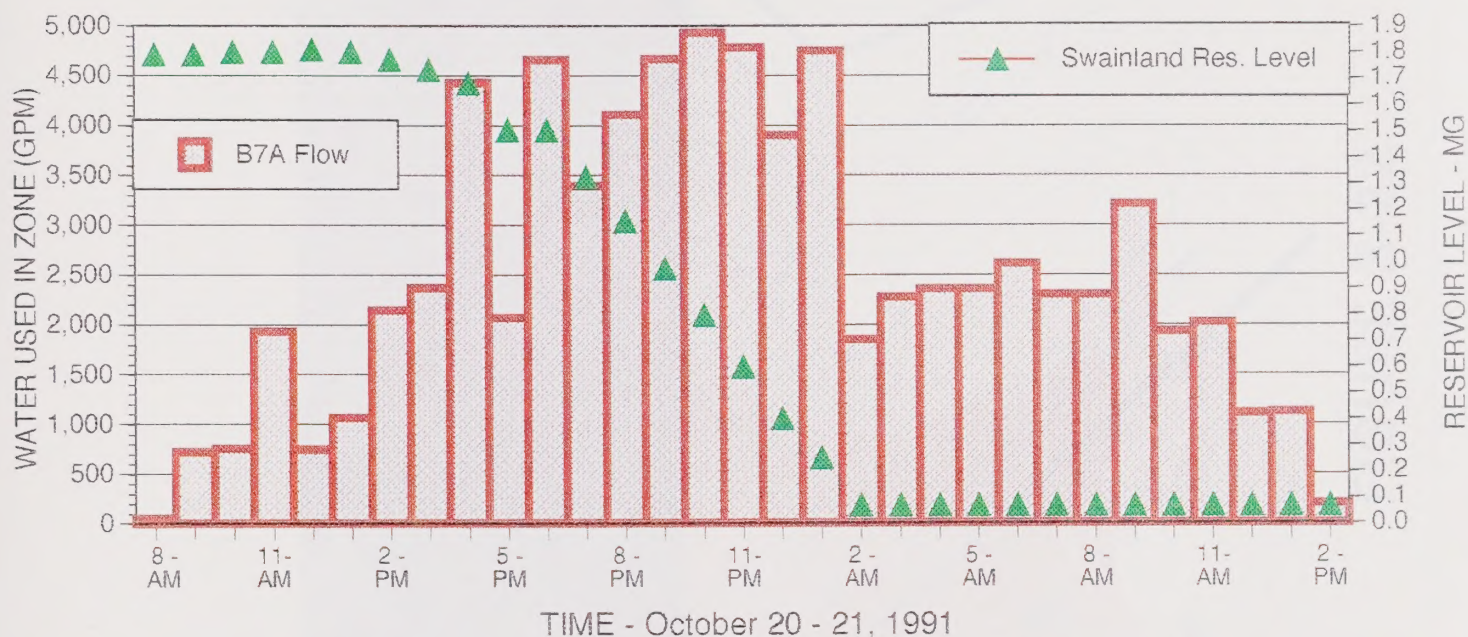
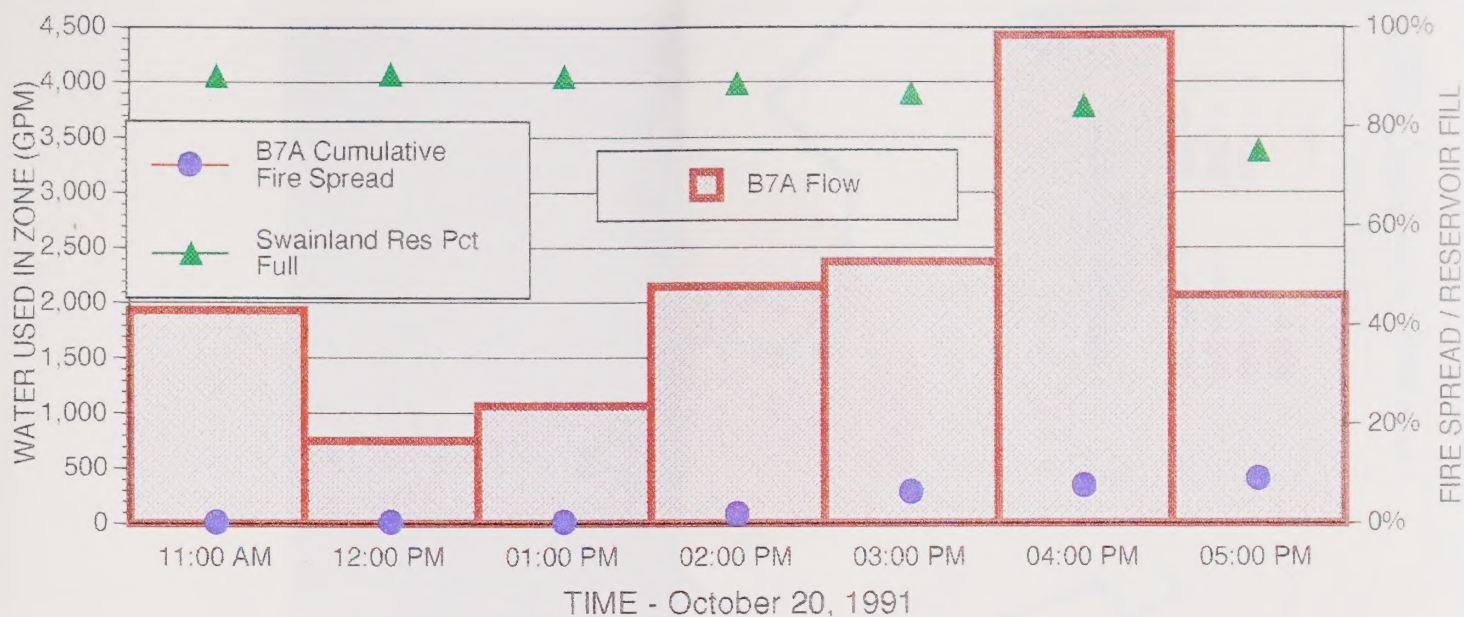
From 11:00 am until 12 noon, water use was about 1,900 gpm. From 12 noon until 2:00 pm, water use averaged 900 gpm. Water use increased to about 2,300 gpm from 2:00 pm to 4:00 pm. Water use increased to 4,400 gpm from 4:00 pm to 5:00 pm. Water use dropped to 2,100 gpm from 5:00 pm to 6:00 pm. Water use averaged about 4,000 gpm for the next 8 hours, after which time the Swainland reservoir was emptied. Thereafter, water use averaged about 2,000 gpm, dropping to about 1,000 gpm by 12 noon October 21.

Water use rates between 2,000 gpm and 4,500 gpm, combined with other factors (firefighting resources, fuel load, weather) were apparently insufficient to stop the continued spread of the fire before 5:00 pm on October 20. Water use rates of about 4,500 gpm, combined with other factors (fire fighting teams, fuel load, weather) were apparently sufficient to stop the spread of the fire after 5:00 pm. The fire spread chronology in the Joaquin Miller zone is shown in Figure 3-22.

For the 21-hour period beginning on October 20 at 2:00 pm, total water provided in the Joaquin Miller pressure zone averaged more than 2,000 gpm. These flows substantially exceeded the current hills area fire flow standard of 1,500 gpm for two hours in both flow rate and flow duration.







### B7A JOAQUIN MILLER PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

FIGURE 3-21









SCALE: 1" = 400'

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FIGURE 3-22

**ESTIMATED FIRE SPREAD PRESSURE ZONE B7A**  
Joaquin Miller

**LEGEND**

|               |      |
|---------------|------|
| SATURDAY FIRE | 1400 |
| 10:05 SUNDAY  | 2000 |
| 10:30         | 3000 |
| 12:00         | 4000 |
|               | 5000 |

FIRE SPREAD INFORMATION FROM CALIFORNIA OFFICE OF EMERGENCY SERVICES AREAS ARE ROUGH ESTIMATES ONLY

**OAKLAND/BERKELEY FIRESTORM**

NOVEMBER 20, 1991  
10:00 AM PST

FILE NO: 100000  
ENCLOSURE  
10-100000  
10-100000





### Thornhill Regulator Pressure Zone B9A

As shown in Figure 3-23, water use in the Thornhill Regulator Pressure Zone B9A averaged about 200 gpm from 8:00 am until 12 noon on October 20. This amount of water usage reflects normal residential use.

From 12 noon until 2:00 pm, water use increased to about 500 gpm. From 2:00 pm until 5:00 pm, water use increased to about 1,400 gpm, until the Thornhill reservoir was emptied.

From 5:00 pm through 2:00 pm October 21, about 300 to 500 gpm was used in B9A, being fed into the zone through the Thornhill Regulator from the B11B Carisbrook pressure zone. The flow into the B9A zone through the Thornhill regulator is estimated at 500 gpm - there are no data recorders or OP/NET instruments to confirm the amount.

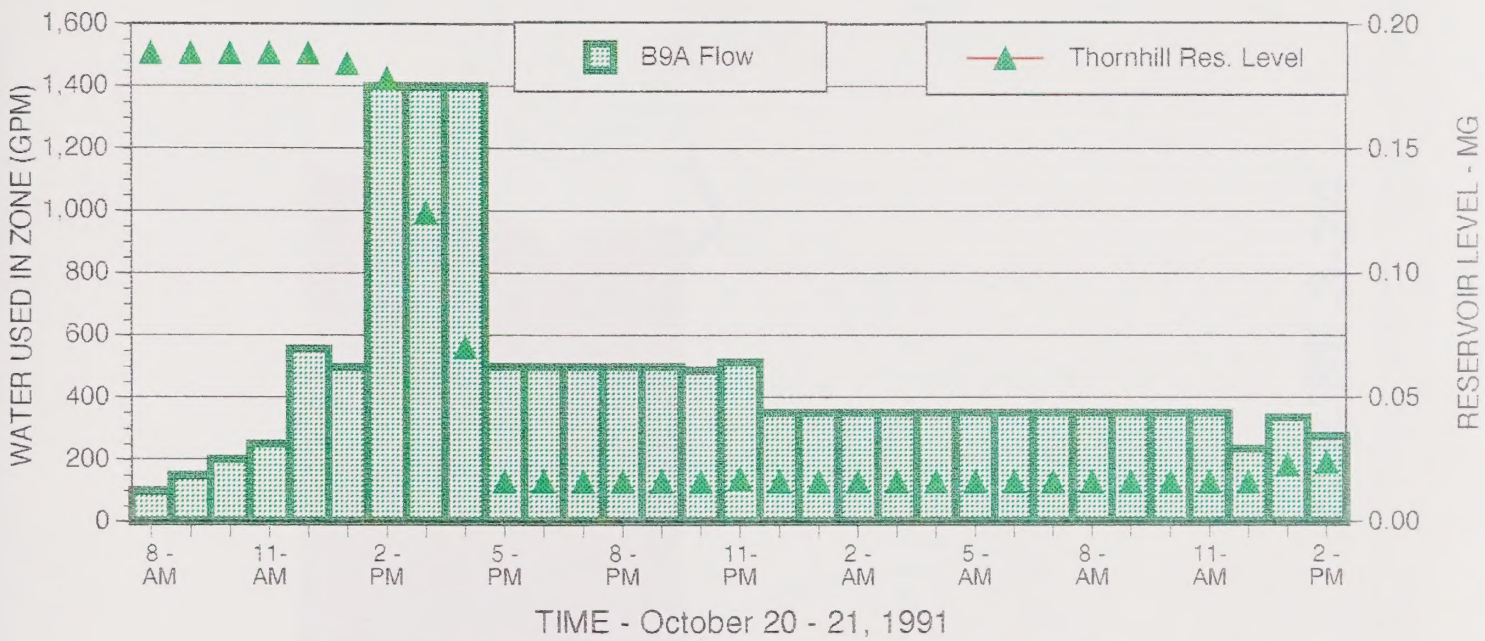
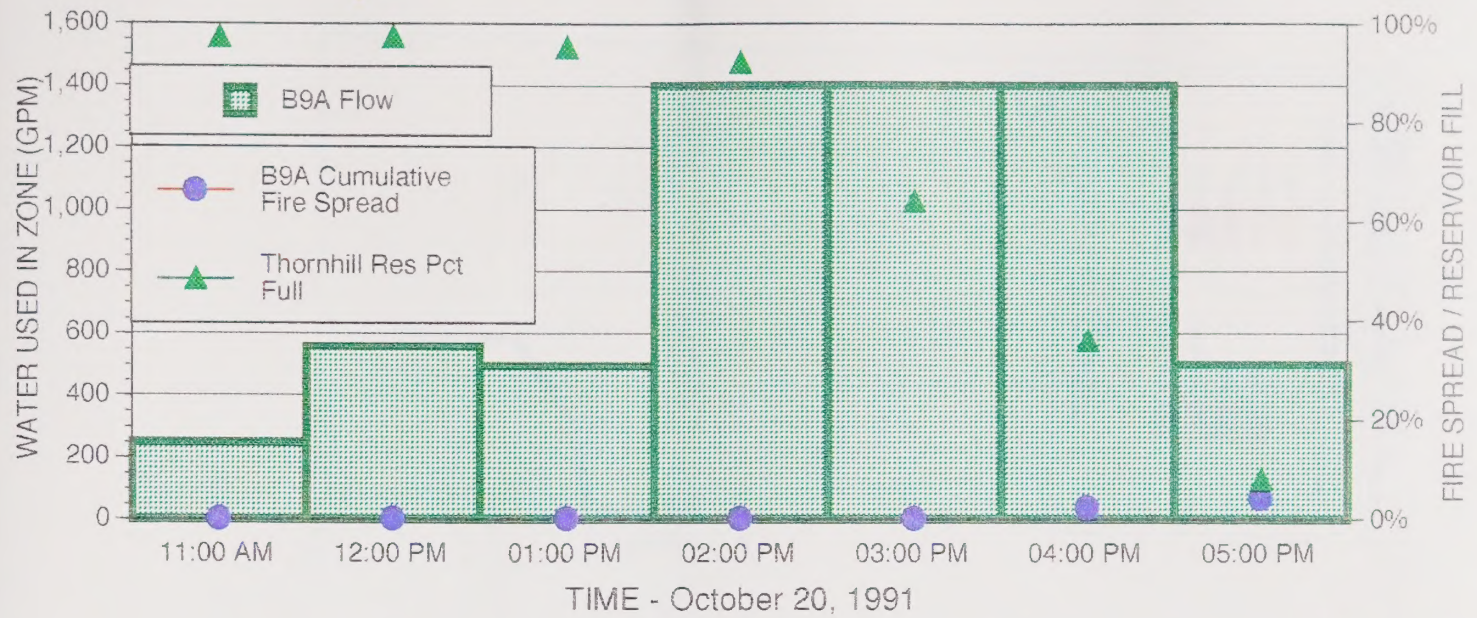
Beginning at about midnight, one emergency pump began operation at the Pinehaven pumping plant, drawing water from the Thornhill zone into the Pinehaven zone. The estimated flow rate was about 150 gpm. Flows could have been pumped continuously, save for the limit of water available in the B9A Thornhill zone. The Thornhill reservoir was effectively empty at this time, and water into this zone was limited by the amount of water available through the Thornhill regulator, about 350 gpm. During the early morning hours of October 21, District personnel augmented this flow rate by temporarily opening zone gates into the B9A zone. The water use data in Figure 3-29 reflect the combined flow of 500 gpm through the Thornhill Regulator and the temporarily open zone gate.

Water use rates of about 1,400 gpm, combined with other factors (fire fighting teams, fuel load, weather) were apparently insufficient to stop the continued spread of the fire before 5:00 pm on October 20. Water use rates of about 500 gpm, combined with other factors (fire fighting teams, fuel load, weather) were apparently sufficient to stop the spread of the fire after 5:00 pm. It should be noted that only a small portion of the B9A zone was involved in the fire, which may, in part, explain why a limited flow of 500 gpm was sufficient (along with fire fighting teams, fuel load and weather) in stopping the spread of the fire. The fire spread chronology in the Thornhill zone is shown in Figure 3-24.

For the three-hour period on October 20, beginning at 2:00 pm, total water provided in the Thornhill pressure zone averaged more than 1,400 gpm. These flows are comparable to the current hills area fire flow standard of 1,500 gpm for two hours.







### B9A THORNHILL PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

FIGURE 3-23



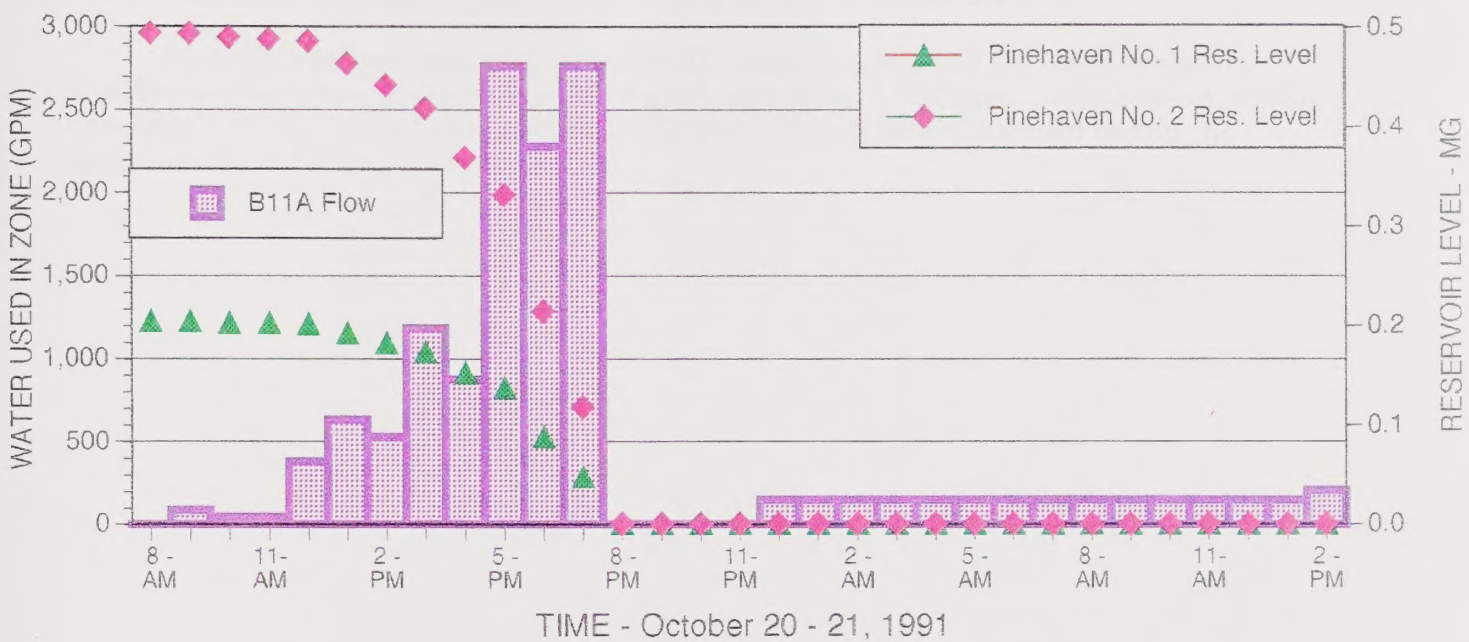
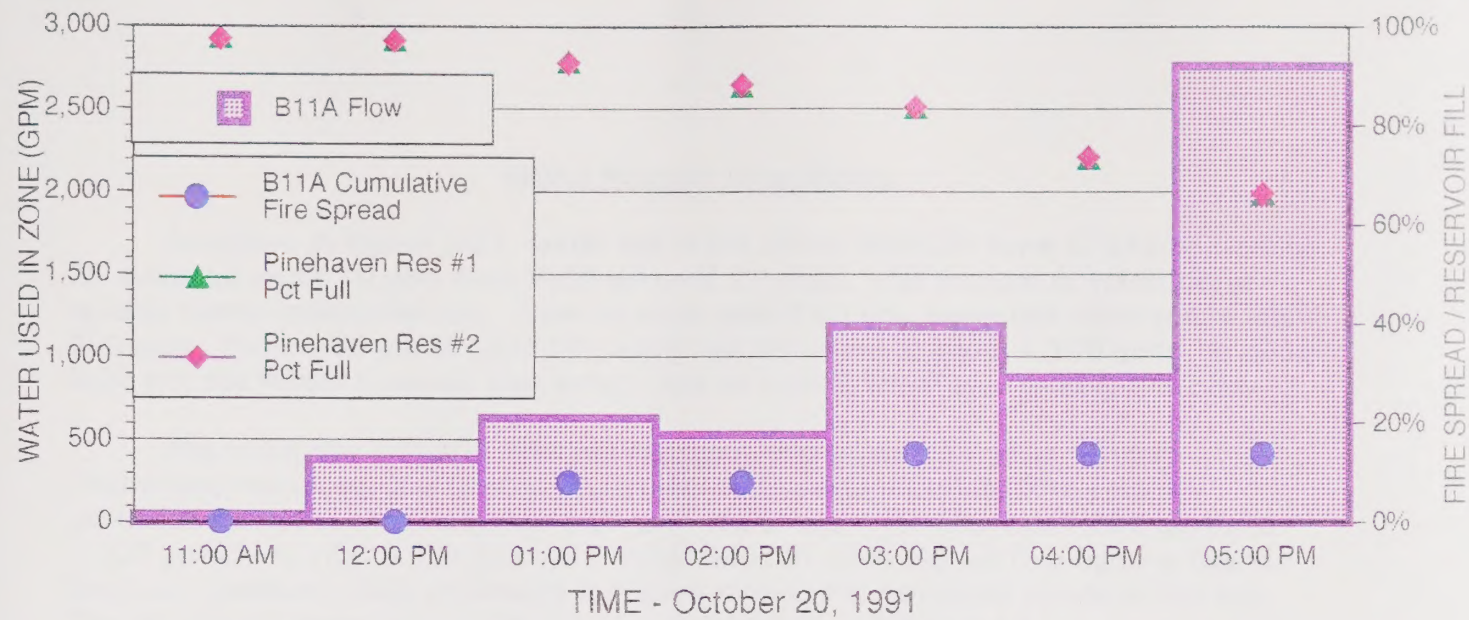












### B11A PINEHAVEN PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

FIGURE 3-25





### Hilltop Pressure Zone B13Aa

As shown in Figure 3-27, water use in the Hilltop Pressure Zone B13Aa on October 20 averaged under 10 gpm from 8:00 am until 12 noon. This amount of water usage reflects normal residential use. From 12 noon until 2:00 pm, water use increased to about 300 gpm. From 2:00 pm to 5:00 pm, water use increased to about 1,100 gpm. At about 5:00 pm, the Hilltop reservoir was empty, and no further water was used in this zone.

The water use between 200 and 400 gpm, combined with other factors (firefighting resources, fuel load, weather) were apparently insufficient to stop the continued spread of the fire before 1:00 pm. Water use rates between 1,000 gpm and 1,200 gpm from 2:00 pm to 5:00 pm, combined with other factors (fire fighting teams, fuel load, weather), were apparently sufficient to stop the continued spread of the fire. The fire spread chronology in the Hilltop zone is shown in Figure 3-26.

For the three-hour period on October 20, beginning at 2:00 pm, total water provided in the Hilltop pressure zone averaged more than 1,100 gpm. These flows, which comparable to the current standard of 1,500 gpm for two hours, sufficed to halt the spread of the fire in this pressure zone.





SCALE: 1" = 400'

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**FIGURE 3-26**

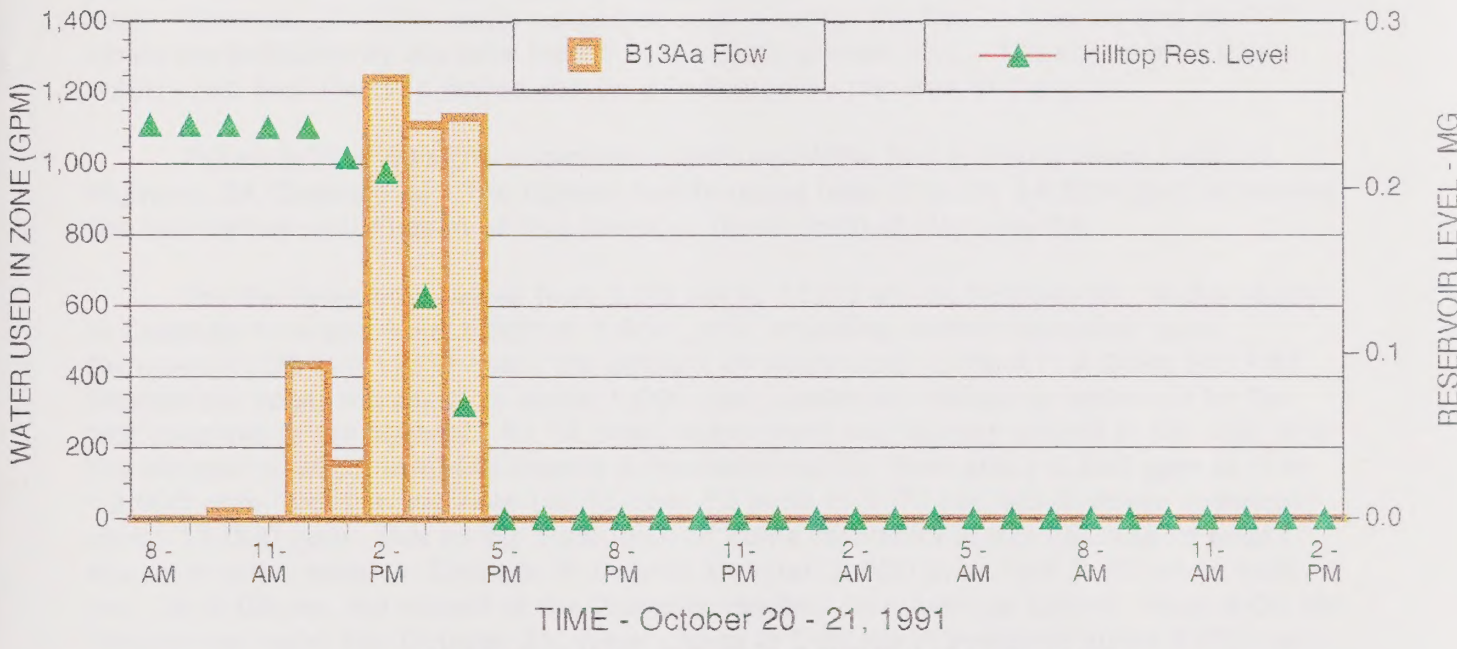
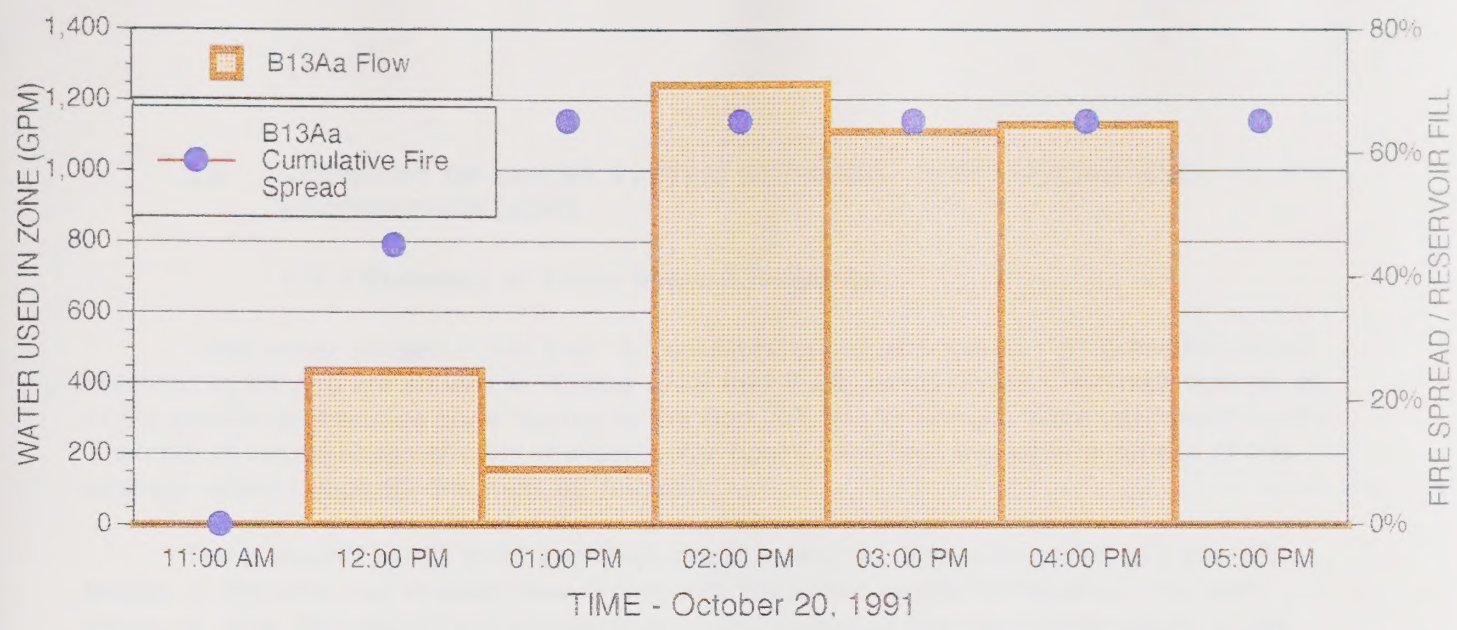
OAKLAND/BERKELEY FIRESTORM  
FIRE SPREAD AREA

REVIEWED BY: J. R. FARRAR  
DATE: 10/15/10  
FILE: 10/15/10  
10/15/10  
10/15/10









### B13Aa HILLTOP PRESSURE ZONE

Note: Bar data are hourly averages;  
Data points are hourly instantaneous values

FIGURE 3-27





### **3.6 SUMMARY OF WATER SYSTEM RESPONSE, CONCLUSIONS AND RECOMMENDATIONS**

#### **3.6.1 Summary of Water System Response**

Total water usages in the five "A" pressure zones and the six "B" pressure zones involved in the fire are shown in Figures 3-28 and 3-29, respectively. In these figures, as in the individual pressure zone figures in Section 3.5, water usages were estimated hourly. The rate of water usage shown at a particular hour is the best available estimate of the average water usage for the next 60 minutes.

The plots in Figures 3-28 and 3-29 are cumulative. For each pressure zone, the height of the area plot at each hour represents the water usage in the zone. For each pressure zone, the area of the corresponding plot indicates the total water usage in the zone. Likewise, the total water usages at each hour for the five "A" zones and six "B" zones are indicated by the total height of the plots at each hour. The cumulative total water used over the time period shown is indicated by the area of the plots.

Figure 3-28 shows the combined water use of the five pressure zones north of Highway 24 (Cascade A). The highest hourly usage rate of nearly 14,000 gpm represents the cumulative water use in all five pressure zones north of Highway 24.

For the three hour period from 8:00 am to 11:00 am on October 20, water usage in Cascade A ranged from 1,000 to 2,000 gpm, reflecting normal residential uses. Between 11:00 and 12:00 noon, the amount of water used in the A11A Gwin and A9B Strathmoor zones increased to about 1,000 gpm combined, reflecting initial use by the first responding fire fighters. By 12 noon, many more fire fighters arrived in the area, and the amount of water used in Cascade A increases rapidly from about 2,500 gpm to over 12,000 gpm. For the two hour period from 12 noon to 2:00 pm, water usage averaged about 13,000 gpm. Due to the drawdown of some reservoirs in this cascade to empty, the total water usage in Cascade A dropped to about 8,000 gpm from 2:00 pm to 5:00 pm. By 5:00 pm, the spread of the firestorm reached its maximum extent. From 6:00 pm through the night into October 21, water usage in Cascade A averaged about 6,000 gpm.

Figure 3-29 shows the combined water use of the six pressure zones south of Highway 24 (Cascade B). The highest hourly usage rate of over 22,000 gpm represents the cumulative water use in all six of these "B" pressure zones.

For the four hour period from 8:00 am to 12 noon, October 20, 1991, water usage in Cascade B averaged around 3,500 gpm, reflecting normal residential uses. Between 1:00 pm and 4:00 pm, water usage averaged about 10,000 gpm. This usage reflects initial fire fighting efforts in the B4Aa Broadway Terrace zone, and substantial fire fighting efforts in the B5A Dingee zone and B7A Joaquin Miller pressure zones. Beginning around 4:00 pm, water usage increased to over 16,000 gpm. Water usage ranged from 16,000 gpm to over 20,000 gpm for the next ten hours. Water usage decreased to about 14,000 gpm between about 2:00 am and 7:00 am, October 21. Thereafter, water usage gradually declined, as fire-suppression efforts were completed, reaching about 4,000 gpm by 2:00 pm October 21.





FIGURE 3-28

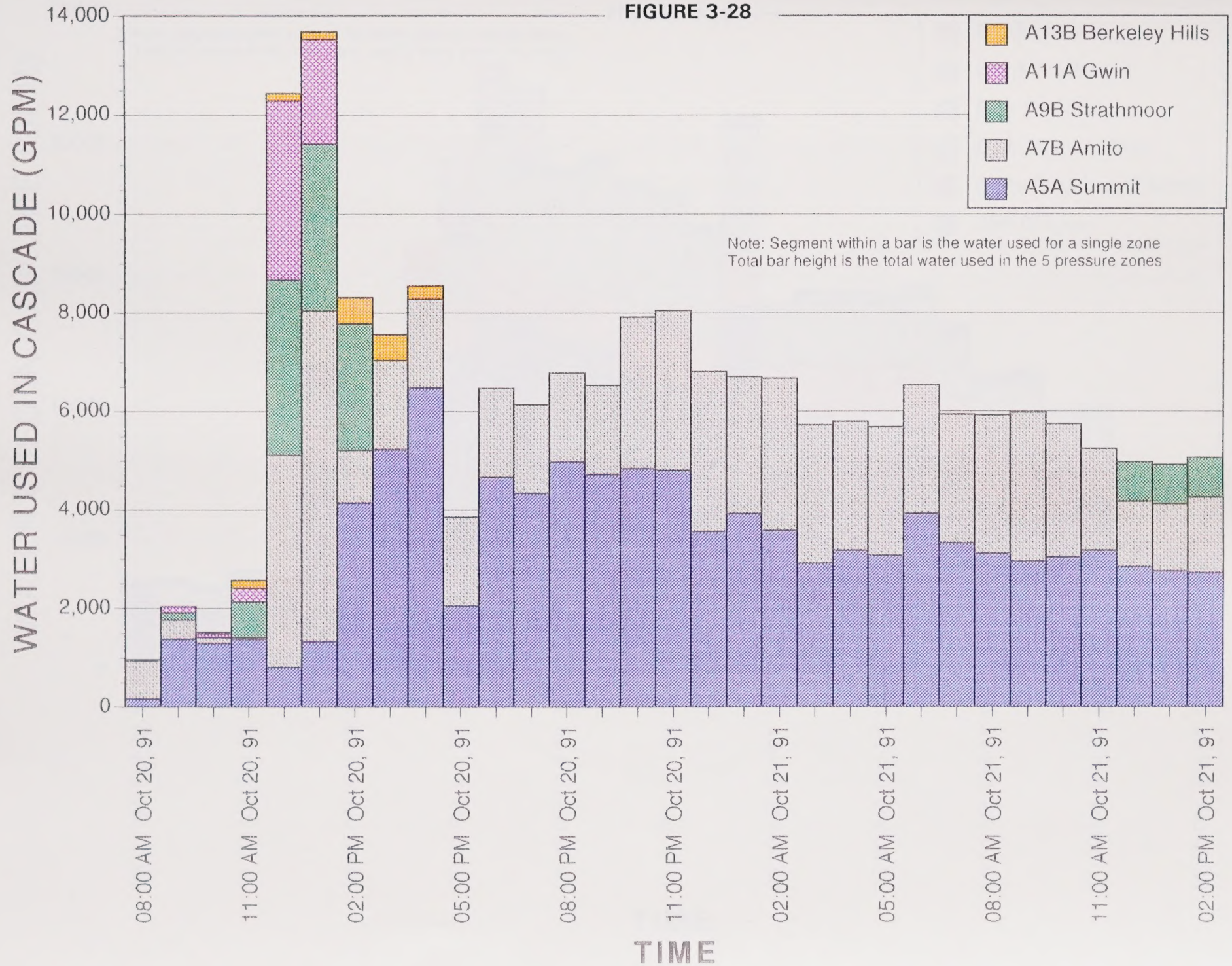
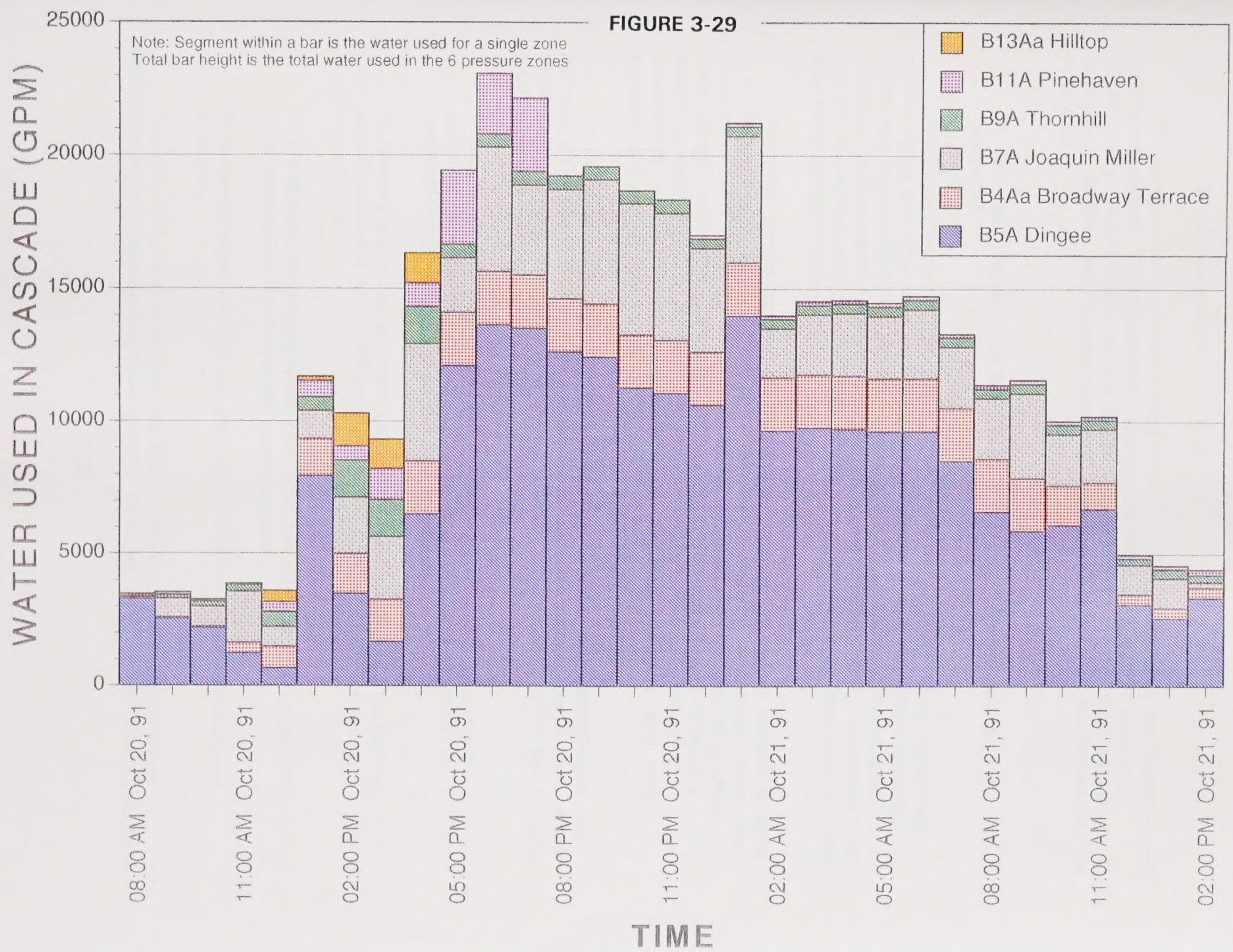






FIGURE 3-29







### 3.6.2 Conclusions

This chapter has presented a large amount of information about the District's water distribution system. This information includes reviews of the system's physical infrastructure, design criteria, pre-fire status, and performance during the firestorm emergency. Based upon this information, the two questions posed in this assessment are answered.

#### **1. How well prepared was the District to respond to the October 20, 1991 firestorm?**

The District's physical infrastructure of reservoirs, pumping plants, distribution system piping, and other hardware has been designed and build over many decades. During this long period of time, design criteria, guidelines, standards, and common practices have substantially evolved. Therefore, maximum available fire flows vary from one part of the District to another, with older portions generally providing lower fire flows than more modern portions.

Over past several decades, the District has completed numerous upgrade projects to increase water storage and improve the distribution system in response to increasing development, and increasing water demands. In the firestorm hills area, for example, water storage capacity in 1991 was 16 times higher than in 1930. The District's current design standards meet the fire flows required by the Oakland and Berkeley Fire Departments for new construction, are consistent with those in use by other water agencies, and are consistent with fire insurance industry guidelines.

At 11:00 am on October 20, 1991 (before the firestorm emergency began), the District's water distribution system was in normal operating status. The District's water distribution system in the firestorm area was generally well-prepared for the fires for which it was designed:

- 1) Reservoirs supplying each of the 11 pressure zones involved in the fire contained water well in excess of the fire-fighting reserves necessary to meet either current or historical fire flow standards.
- 2) Pumping plants had sufficient capacity to maintain specified fire fighting water reserves under conditions of maximum daily water use for normal consumption.
- 3) Distribution pipe sizes in most areas were consistent with providing fire flows at or above current and historical standards.
- 4) Hydrant spacings in the burn area were consistent with common design practices.

However, in some older (mostly pre-1930) portions of the District's water distribution system, pipe diameters are too small to deliver very high fire flows. Therefore,





in these areas the District's water distribution system was less well-prepared than in more modern portions of the system.

Furthermore, because of the extreme water demands generated by the huge extent of the October 20, 1991 firestorm, the District's system ran out of water in some areas at some times, even in areas where the system completely meets today's fire flow standards. Therefore, although the system was generally well-prepared for the fires it was designed to meet, it was not fully prepared to supply the extreme quantities of water demanded during the October 20, 1991 firestorm.

Substantial reservoir size increases, pumping plant size increases, and upgrades from four-inch distribution piping would be required to supply water to many simultaneous fires within a single pressure zone. Such distribution system improvements, well beyond that required by current fire flow standards, would enhance the water system's ability to respond to multi-fire emergencies. However, reducing future fire hazard threats requires a comprehensive coordinated effort among fire agencies and residents as well as the District. Augmenting hazard mitigation measures may be as important as enhancing emergency response capabilities. As described below in Section 3.6.3, there may be other more cost-effective approaches to improving total fire suppression capabilities and reducing the risk of re-occurrence of this type of catastrophe.

## **2. How well did the District respond to the firestorm emergency?**

Estimates of the amounts water provided by the District to each of the 11 pressure zones involved in the fire were compiled in Section 3.5. Nine of the 11 pressure zones delivered fire flows well in excess of the current hills area fire flow standard of 1,500 gpm for two hours. Several pressure zones provided flows which were many times this fire flow standard. The Hilltop pressure zone provided flows comparable to the current standard; these flows sufficed to halt the spread fire in this zone. In the Berkeley Hills pressure zone, fire suppression efforts required only about 500 gpm; higher flows would have been available if they had been needed.

Based on the quantities of water provided in each fire-area pressure zone, the District's water distribution system generally responded well to the fire emergency. However, the extreme water demands imposed by the firestorm emergency exceeded the District's capability to supply water in some areas at some times. Therefore, available fire flows were limited in some areas at some times. These water supply limitations had three principal causes:

- 1) Extreme water demand due to fire suppression efforts and losses from flowing service connections at burned structures,
- 2) Overdrafting by firefighters simultaneously drafting from many hydrants in a single pressure zone, and
- 3) Distribution system limitations (small pipe diameters in older (mostly pre-1930) portions of the system).





However, power failures at pumping plants did not have a substantial effect on water availability during the peak water demand period of the firestorm. If the power failures had not occurred or if immediate emergency power had been available, the additional water supplies which would have been available in pressure zones where limitations occurred during peak demand times would have been less than ten percent of the water quantities supplied by the system.

The availability and efficacy of water for fire suppression during the firestorm emergency varied substantially, depending on the time and location. In some areas, where other important fire-suppression factors were relatively favorable, moderate to very high fire flows sufficed to halt the spreading firestorm. In other areas, where other important factors were less favorable, very high fire flows (well above current standards) were insufficient to halt the spreading firestorm. Fire flow limitations impeded fire suppression efforts in some areas at some times during the firestorm, particularly in the Broadway Terrace and Dingee Pressure Zones.

### **3.6.3 Recommendations**

The recommendations outlined below are based on our Phase I assessments. More detailed recommendations, considering a range of alternatives, will be developed under the Phase II work program.

#### **1. Upgrade Older Portions of the Water Distribution System to Current Fire Flow Standards**

The District should develop a benefit-cost strategy for identifying the most at-risk areas in its system which do not meet today's fire flow standards. A systematic, prioritized long-term approach for pipe replacement and facility upgrades for these areas should be established. The District should consider installing pumper hydrant interconnections between all pressure zones in high fire risk areas. In considering possible water distribution system upgrades, lengthy periods of time before the final upgrade design is implemented are often necessary to involve the community and to balance competing needs. The District should review financing policies and establish criteria to determine whether the cost of such upgrades should be borne by the service areas benefiting from the upgrades or by the entire District.

#### **2. Modify Current Fire Flow Standards**

During the course of the October 20, 1991 firestorm emergency, several of the District's reservoirs were emptied. The reason that these reservoirs were emptied was not that the reservoirs were incorrectly designed - they all met today's standard of having fire fighting reserves to provide fire flows of 1,500 gpm for two hours in each pressure zone. Rather, the prime reason the reservoirs emptied was that the firestorm conflagration that occurred was far and beyond any size fire that was considered in the design of the water system. Therefore, extreme water demands exceeded the system's ability to provide water.





One option is to consider increasing today's fire flow standards from 1,500 gpm for two hours to some higher flow rate and some longer duration. This choice is an expensive one to implement, especially in the existing built-up areas of the EBMUD service area. Some of the recommendations below may be more cost effective in obtaining similar improvements in fire fighting capability.

### **3. Encourage Mitigation Actions**

Widespread use of shake roofs and other non-fire-safe construction practices contributed significantly to the rapid spread of the fire. If all houses in the area had had Class A clay tile or other non-combustible roofs, and other fire-safe construction details, it is possible that the extent of the firestorm would have been considerably reduced. The cities of Oakland and Berkeley should strictly enforce standards requiring that new structures built in the firestorm area be built with tile or similar roofs and that new structures fully conform to current fire-safe construction practices. It would also be highly desirable to rid the high fire risk areas of shake roofs. This fire-safety enhancing process could be mandated by city rules at time of sale, at time of substantial structural improvements, or when re-roofing occurs.

The high vegetative fuel load in the burn area also contributed greatly to the fire's rapid spreading and exacerbated difficulties in its suppression. Strict control of vegetative fuel loads in high fire hazard areas would substantially reduce future fire risks. Additional actions should be taken to rid high hazard areas of fuel load caused by severe freezes.

### **4. Enhance Pumping Capability**

Several pumping plants lost PG&E power during the firestorm. The analysis presented in this report suggests that if PG&E power had not been lost at any time at any pumping plant, or if the District had immediate use of emergency backup power, the amount of additional water available to fight the fire would have been only modestly incremental: perhaps an additional 1,250 gpm split between pressure zones A7B, A9B or A11A; and perhaps an additional 400 gpm split between pressure zones B11A and B13Aa, if limitations on the feed into the B9A pressure zone were upgraded.

The Summit (A5A) and Dingee (B5A) pressure zones lost their main source of water supply when PG&E power failed at the Claremont Center. However, these same zones had substantial intra- and inter-zone ties, so that they were able to draw water from remote reservoirs and pumping plants outside the firestorm area. Therefore, shortage of water due to pumping plants out of service, was not a substantial problem in these zones.

The District had sufficient numbers of back-up generators and portable pumps to serve the affected pumping stations - however, due to the size and intensity of the fire, the times necessary to mobilize and install this equipment made them unusable for many hours into the firestorm. The District has distributed this emergency equipment around the service area to allow more rapid mobilization to any affected area, in case of fire, earthquake or other emergency situation.





Past experience with the reliability of emergency diesel generator has not been entirely satisfactory. For example, in the recent Santa Barbara fire, one such emergency diesel did not run, reportedly due to oxygen starvation from the intensity of the surrounding fire. Under non-emergency situations, a recent survey<sup>23</sup> found that 42% of water pumping plant emergency generators failed at least once per year.

The extreme water demands experienced during the firestorm did result in the emptying of several reservoirs at elevations above 700 feet. This problem could be addressed in several ways:

- back-up power or pumping could be provided faster for these higher elevation zones.
- pumping plants could be upgraded to be able to pump at a faster rate (at least the fire flow rate).
- these zones could be interconnected with parallel zones at similar elevations to allow access of water from remote reservoirs and pumping plants.
- these zones could be provided with larger reservoirs, to allow fire flows for longer durations.
- some zones could be provided with emergency pressure regulators, to allow access to water from reservoirs stored at higher elevation zones.

## **5. Increase Attention to Fire Flows Under Normal Operation and Limit Temporary Operations**

Under normal operations of the water distribution system, pumping plants and reservoirs must be temporarily taken out of service for normal maintenance, construction upgrade, or other reasons. The District's Operations Division currently decides whether such efforts can be accommodated by the system, while still retaining adequate capacities to fight fires. The need to perform maintenance, and the need to maintain fire flows in otherwise non-redundant parts of the system, can result in conflicting decisions. Often, a temporary bypass is provided to provide a limited amount of water flow while the maintenance is performed. Although judgement is ultimately required to decide these operational issues, it is suggested that procedures be developed that limit the temporary extent of exposure of the system to reduced fire flow capacities.

Similarly, unusual occurrences will sometimes disrupt parts of the water distribution system. In the early 1980s a landslide occurred on Armour Drive, in the Oakland Hills. This landslide broke a pipe which connected the Forestland Reservoir to the northern parts of the B9A pressure zone. The emergency repair that the District performed was to install a new "temporary" regulator to drop water into the isolated area from the B11B zone. This temporary repair was not as robust as the original design, and fire flows available to the area were limited. District personnel were aware of this issue, but reportedly, the





City of Oakland decided not to rebuild the road in the landslide area or to stabilize the slope. This temporary fix has lasted eight years.

Similarly, the three emergency reservoirs installed in the firestorm area in 1973 (Berkeley Hills, Roundtop and Hilltop) were originally designed to allow very rapid construction. These reservoirs are built from redwood, not the steel or concrete which would have been used for more permanent facilities. At the time of construction, the District classified the reservoirs as "temporary emergency" facilities. Today, these reservoirs have been in service for almost 20 years, and a growing number of residential services rely upon these reservoirs as their sole source of water. These three reservoirs are not designed to accommodate strong earthquake motions, and may fail under future large earthquakes along the Hayward Fault.

It is easy to let "temporary" projects to become "semi-permanent" if they continually perform well under normal operations. However, the District must be prepared for both "normal" and "emergency" modes of operations. The District should adopt a more rigorous policy of ensuring that "temporary" facilities are restored on a timely basis to full design capacities, consistent with the risks posed.

## **6. Improve Document Control**

During the course of the firestorm, operations personnel were unaware that the Caldecott regulator was on standby status. Operations personnel need to have current information as to the status of all such hardware in the system, especially under emergency conditions. Therefore, document control mechanisms must be modified to accommodate this information flow.

## **Chapter 3 Endnotes**

1. Report on the City of Oakland, CA, National Board of Fire Underwriters, Report No. 134, July, 1933.
2. Personal Communication, R. Rago (EBMUD) to J. Eiding, June 2, 1992.
3. Grading Schedule for Municipal Fire Protection, Insurance Services Office, 1974.
4. Guide for Determination of Required Fire Flow, Insurance Services Office, December, 1974.
5. Fire Suppression Rating Schedule, Insurance Services Office, 1980.
6. Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions, National Board of Fire Underwriters, 1956.
7. R.C. Kennedy, The Capacity Requirements and Design of Distribution Reservoirs,





Journal of the American Water Works Association, Vol 32, No. 11, November 1940.

8. ESP 001, Index, EBMUD Engineering Standard Practice, Effective February 7, 1990.
9. ESP 492.1, Water Main Planning Criteria, EBMUD Engineering Standard Practice, Effective October 17, 1985.
10. ESP 492.2, Distribution Reservoir and Pumping Plant Planning Criteria, EBMUD Engineering Standard Practice, Effective January 1, 1985.
11. ESP 492.1, Water Main Planning Criteria, EBMUD Engineering Standard Practice, Effective May 1, 1979.
12. ESP 492.2, Distribution Reservoir and Pumping Plant Planning Criteria, EBMUD Engineering Standard Practice, Effective May 1, 1979.
13. Procedure 8-76, Water Service Estimates, EBMUD Procedure 8-76, Effective February 2, 1976.
14. Personal Communication, G. Cates (Berkeley Fire Department) to J. Eiding, June 12, 1992.
15. Environmental Impact Report (Draft), Water Service From Emergency Facilities in the North Oakland Hills Area, EBMUD, October 1983, and Final Environmental Impact Report, Water Distribution Facilities - Oakland Hills Area, Pinehaven, Strathmoor, Amato and Peralta Pressure Zones, EBMUD, January 1988.
16. Letter, G. G. Taylor, Oakland Fire Chief, to R. Kolm, EBMUD Asst. Chief Engineer for Planning, dated April 30, 1987.
17. Brown and Caldwell, Blackhawk Water Use Study, 1982.
18. Personal Communication, K. Miller (EBMUD) to J. Eiding, June 2, 1992.
19. Facility Guide, EBMUD, 1988.
20. Comments on Water Supply Issues During the East Bay Hills Fire, Compilation of After-Action Reports and News Media Reports, VSP Associates, Inc., May 21, 1992.
21. Personal communication, M. Louis, EBMUD, to J. Eiding, June 2, 1992.
22. Personal communication, R. Rago, EBMUD, to J. Eiding, June 2, 1992.
23. Reliability of Standby Engine-Driven Generators at Water Purveyors Pumping Facilities, A. A. Webb Associates, April 27, 1992.





## **4.0 THE DISTRICT'S EMERGENCY RESPONSE**

### **4.1 Introduction**

This chapter describes the general context of emergency management and assesses how well the District was prepared to respond to this emergency and how it actually did respond. Like many aspects of management and organizational behavior, emergency management has numerous dimensions, making it difficult to evaluate performance. Nevertheless, using two sets of assessment criteria we collected a variety of documentary and interview data. From this information we reached several findings, and are able to make recommendations designed to improve the District's abilities to manage any likely contingency.

Section 4.1 provides background information on emergency preparedness and the scope of emergency preparedness programs. Section 4.2 summarizes the principal findings with respect to the District's emergency preparedness and emergency response. Section 4.3 provides detailed assessments of the District's preparedness and response, from an emergency management perspective. Section 4.4 summarizes recommendations to enhance the District's preparedness and response in future emergencies.

#### **4.1.1 Understanding Emergency Preparedness and the Participation of Special Districts**

The basic philosophy of emergency preparedness is to create capabilities within an organization so it can manage its affairs and continue to operate to the best of its abilities under abnormal conditions. There are no requirements, however, in California's Emergency Services Act that require local agencies like EBMUD to have emergency management plans or programs unless a local governing body appoints itself to be an "Emergency Council." Then the Act's provisions require that certain preparedness activities be undertaken. Local governments generally participate in such activities because they are committed to it, have experienced or expect to be effected by major disasters, or receive matching Federal funds through the Emergency Management Assistance (EMA) program. Simply stated, there is no standard in the field for utility disaster plans.

Nevertheless, there are numerous sources of information designed to help such organizations prepare for emergencies. The California Office of Emergency Services distributes "Multihazard Functional Planning Guidance" (MHFPG) to support this process, and all recipients of EMA funds must use this guidance for their plans. EBMUD does not participate in this program, and there is a real question about whether special districts are eligible applicants. Virtually all participants are city and county governments. In fact, special districts and similar regional or multijurisdictional agencies often are not well integrated into traditional local and state government emergency management planning processes or operations.





#### **4.1.2 The Scope of a Preparedness Program**

While there are no specific standards or requirements, what would constitute an adequate level of emergency preparedness? An "ideal" situation for the District would have been a program that included several elements. Basic information about all hazards likely to affect the District should have been gathered and used as a foundation for a comprehensive emergency planning program. The Board and top management should have defined policy and general responsibilities for the program, and there should have been regular staff resources committed to the program. District personnel should have been active on committees and other groups that helped integrate the District's efforts with those of other agencies and organizations. Critiques of previous emergencies should exist as part of a constant improvement process. The District should have been included in various alert, warning, and notification systems so it could have received timely information on which to base its reactions.

A comprehensive emergency operations plan should have existed, and it should have been supported by various detailed functional operational plans and standard operating procedures. Various kinds of emergency action information, training, and drills and exercises should have been conducted regularly. The District should have had various mutual aid and other agreements in place to either provide or obtain support under emergency conditions. Communications systems should have been adequate for emergency operations, including special ones if needed. Basic emergency supplies and equipment should have been on hand and located in places throughout the District. Procedures for assessing damages and preparing claims should have been developed, and thought should have been given to providing emergency public information to the District's customers.

#### **4.2 Principal Findings**

When answering the question "How well prepared was the District to respond to the firestorm?" it is important to specify with what the District is being compared. If the District's degree of preparedness at the time of the firestorm is compared with preparedness at other utilities in California, then the District was far better prepared to deal with a major disaster than many, and not quite as prepared as some.

We noted, however, that even in the absence of some preparedness measures, the District Emergency Operations Center (EOC) staff responded effectively to the firestorm. While the District's emergency management efforts, which were almost totally operations-based, were reactionary, everything that needed to be done was accomplished.

This chapter's assessment of the District's preparation for and response to this emergency is from the emergency management perspective. In many cases the District did not have a full or ideal emergency management plan in place. However, District staff are well trained and experienced in dealing with emergencies. Therefore, in most cases, effective actions based on experience, judgement, and common practice were taken, even without detailed emergency management plans being in place.





When discussing our findings about the District's overall response to the firestorm, it is helpful to divide the discussion into three components -- emergency management, field response, and recovery.

#### **4.2.1 Emergency Management**

1. Other than the Board directive to update the Disaster Plan after the Loma Prieta Earthquake, there was no standing District-wide policy direction regarding the development, maintenance, and testing of comprehensive or operational emergency plans by departments and divisions before the firestorm. This item has been partially addressed by a recently adopted District Board mission statement.

2. No overall hazards assessments had been completed for the potable water system, and although some planning and training had been done and studies were underway, the probability of a major firestorm had not been recognized as a likely scenario in the existing plans. The Wastewater Department has conducted a hazards assessment as part of its emergency planning.

3. While various emergency operations plans had been prepared and exercised occasionally, the absence of a comprehensive District-wide management and administrative level EOP inhibited the response to some degree at that level and required more ad hoc arrangements to tie various elements of the District together than might have been true otherwise. The major problem with an operations-based planning approach from an emergency management perspective is not that it does or does not address earthquakes, fires, or other specific contingencies, but that it does not contain specific roles and responsibilities and an overall concept of operations which can be applied in all types of emergencies.

4. Because the EOC organization lacked specific roles and responsibilities, expectations of EOC staff were unclear. This, coupled with the absence of a designated emergency communications network with cities and fire departments, and the loss of the OP/NET system information from the fire area, made internal and external intelligence gathering, sharing and analyzing more difficult.

5. The lack of a specific EOC organizational structure, the physical layout of the facility, and interruptions to provide visitors and the news media with status reports generated a degree of unnecessary stress among EOC staff. Since no EOC staff members were designated as interagency liaison before the emergency, contacts with Pacific Bell and PG&E to coordinate restoration efforts may not have been made as early in the incident as they could have been.

6. Criteria had not been pre-established (other than for earthquake) for activating and deactivating the EOC. Because the magnitude and scope of this event only became clear over time, some key staff did not report to the EOC until mid-afternoon. Emergency instructions to customers regarding limiting water usage to preserve water for fire suppression efforts were not disseminated until late in the afternoon. However, up to that time, the priority for public emergency instructions was on evacuating people in the fire





area.

7. Various detailed operating procedures existed for parts of the organization and to support some of the plans. However, there are several instances where the presence of such procedures, checklists, and similar documents would have improved the District's response.

8. A contributing factor was Alameda County's not being designated as an Operational Area for emergency operations purposes. Such a designation, if properly implemented, helps ensure coordination among all municipalities and special districts. Efforts are underway, supported by all of the cities, to have Alameda County so designated. The District is a member of the task force addressing this problem. Also, the lack of integrated communications systems and procedures to coordinate with local organizations is of concern.

#### **4.2.2 Field Response**

1. Field response was hampered by the uncontrolled nature of the fire which affected all utility systems, including PG&E's. Emergency generators and pumps were in storage for transport and use as needed during emergencies. Since the fire burned through some of the pumping plants and damaged one of the reservoirs, and since diesel-driven generators and pumps may have been damaged by the intense heat, it is unknown if having them at facilities in the burn zone would have made a difference.

2. The main route between the eastern and western portions of the District (Highway 24 and the Caldecott Tunnel) was cut off for most of the afternoon. This delayed crew response to the District and limited access to needed portable generators and pumps, the bulk of which were stored east of the Tunnel. However, when generators and pumps were available in the fire areas, crews still had to wait for the fire to be contained to gain access to affected pumping plants.

3. Given the nature of this fire, the District's field response was quite good. From the beginning of the event, field crews were out in the fire area checking the status of reservoirs and pumping plants, opening zone gates, shutting off ruptured services, working fire lines, and providing communications links and requested resources to fire departments.

#### **4.2.3 Recovery**

1. Except for the District's customers who lost structures in the fire and whose service connections had to be closed after the fire passed, the District was able to restore normal water service to the remainder of its customers by 12:00 Noon on October 22. The District established a customer hotline as soon as the emergency response phase was completed. The Board expeditiously adopted emergency policies regarding water use and reconnection charges and special leave for employees whose homes were lost. District staff have been designated to participate in multiple community-wide emergency planning task forces and committees.





2. One weakness was the lack of any formal critique of the District's response or debriefing and counseling for District employees, especially those who lost their homes in the fire.

### **4.3 Discussion**

#### **4.3.1 Emergency Preparedness in the District**

The preparedness assessment criteria guided the collection of documentary and interview data for this element. In sum, the major preparedness subjects discussed below include: 1) emergency planning, 2) training and drills, 3) mutual aid and intergovernmental agreements, 4) communications systems, 5) damage assessment and impact evaluation, 6) equipment and supplies, 7) customer relations and public information, and 8) related activities.

##### 1) Emergency Planning

As noted earlier in the report, providing potable water and water for fire suppression are two of the primary missions of the District. Providing fire flows has been considered in many aspects of the District's water system: planning, design, construction, operation, and management. Information about available fire reserves, design fire flows, and the status of the water system before the fire is given in Section 3.0 of this report. The pre-fire status of emergency management planning and related activities in the District is reviewed below.

Planning for small-scale, "ordinary emergencies," such as pipeline breaks, is an integral part of normal water system operations, with well-determined, frequently-implemented emergency response procedures. To plan for larger scale emergencies the District has established a Disaster Committee, chaired by the Manager of Water Operations, who also serves as the District's Disaster Officer. The Disaster Committee is composed of the managers of Water Operations, Plant and Equipment Maintenance, Distribution Maintenance, Construction, Engineering Services, Wastewater Treatment, Water Supply and Distribution, and Water Treatment. All of the committee members have water utility emergency operations experience. The Disaster Committee Chairperson reported regularly to the General Manager.

First Maintenance and then the Operations Department was responsible for developing and maintaining the District's Disaster Plan. As part of the District's emergency planning process, the Disaster Officer directed various supervisors to develop facility emergency plans and procedures. All managers and supervisors were oriented to the upgraded October, 1990 District Disaster Plan early in 1991. The Disaster Committee met twice-monthly during development of the updated Disaster Plan.

Utilities are both publicly and privately owned, and in general most, including the District, have emergency plans which are operations-based rather than emergency management-based. This is an important distinction because operations plans tend to





prescribe very detailed steps for inspecting or doing things to the equipment, infrastructure, or facilities. The intent of an ideal emergency management plan, however, is to support the mobilization of the entire policy, management, and administrative elements of the organization so they can effectively perform their specified duties. Thus, specification of roles and responsibilities is usually much broader in an emergency management plan than usually specified in operations-oriented plans.

The District's 1990 plan was developed using the highly operationally-oriented Southern California Water Agency's Plan as a model. Also, the Disaster Plan in place at the time of the fire was earthquake-specific because earthquakes were judged to be the greatest threat to the District as a whole. Section 3 of the plan outlines an Emergency Management Organization (EMO) comprised of members of the Disaster Committee, and calls for activating, staffing, and operating an Emergency Operations Center (EOC). It does not, however, contain provisions and/or criteria for declaring a District emergency or define internal emergency authorities and powers during such events, or address several other subjects. These subjects include an overall concept of operations, direction and control, external agency liaison, resources management, and public information. Other emergency management elements may be needed as well.

Continuity of management for operations was emphasized in the plan, but not general management or District-wide administration. Procedures for ensuring that key operations and maintenance personnel report to the District following a disaster were in place, as was a communications plan that provides for primary and alternate communications capabilities. Operations priority action checklists were available. However, they had not been prepared for the EOC staff, which is the Disaster Committee and is charged with compiling information and coordinating all District activities.

The District's 1990 plan was submitted to the California Office of Emergency Services' Utilities Section; the Chief of Utilities stated that he believed it was a good plan. However, there is no comprehensive guidance for utilities comparable to that which exists for local, state and federal governments. Some planning assistance is available. For example, the California Department of Water Resources provides emergency water operations preparedness guidelines, and the Utility Policy Committee (of OES) has prepared a Self-Assessment Survey for utilities to use in evaluating their plans.

Following the Loma Prieta Earthquake in October, 1989, the Board directed staff to update the Disaster Plan, and it authorized the purchase of additional emergency equipment, such as portable generators, portable lights, and additional repair supplies. A table-top exercise was held on April 11, 1991. Following the firestorm, additional work was done on the 1990 plan. In addition, changes were recommended in the layout of the District's EOC. Also, a study was commissioned to assess the seismic vulnerability of all District facilities. This project was underway at the time of the firestorm.

In addition to the revised District-wide Disaster Plan, a Special District No. 1 (Wastewater Department) Contingency Plan, a Purchasing Division Emergency/Disaster Plan, and a Water Department Earthquake Operations plan were in place at the time of the fire. A Distribution and Maintenance Division Emergency Manual was being developed, but it was not yet completed. The Watershed Manager had also developed a Wildland Fire





Plan in cooperation with the East Bay Regional Park District (EBRPD). The Wildland Fire Plan is updated annually.

Prior to the firestorm the District participated in several emergency planning groups. The Disaster Officer was on the State's Utility Policy Committee. The Plant and Equipment Maintenance Division Manager serves on the Alameda County Emergency Managers Group and the Contra Costa County Emergency Resource Committee. The Watershed Manager is liaison to the EBRPD and the Hills Fire Chiefs Group. At various times, the Superintendent of Water Distribution, and the Manager of the Wastewater Treatment Division attended emergency planning meetings conducted by the City of Oakland.

## 2) Training and Drills

District rangers in the Watershed Division participated in joint training and drills with EBRPD personnel, and some had attended the California Department of Forestry and Fire Protection's (CDF) Academy for wildland fire protection training. The District Safety Manual requires those working in confined spaces to be trained and certified in the use of self-contained breathing apparatus (SCBA) and cardiopulmonary resuscitation (CPR). Employees were encouraged to take District-sponsored first aid and CPR training.

The Watershed Division participates in annual training exercises with EBRPD, and other personnel participate in state-mandated dam safety warning and evacuation drills. The Wastewater Division conducts annual drills involving its senior management and all levels of its site-level EMO. District-wide disaster exercises, however, were not routinely conducted, and there was no formal District policy regarding the organization and conduct of disaster training and drills.

## 3) Mutual Aid and Intergovernmental Agreements

Prior to the firestorm the District was signatory to a number of mutual aid agreements. These included an agreement between the Wastewater Division and Alameda County Sanitary Advisory Commission District (April, 1991); one between the District and Contra Costa County and the Alameda County Flood Control and Water Conservation District (1983); and one between the District and Southern California Water Agencies (1975).

All of these agreements contained the same general provisions - namely assistance in the form of resources such as heavy equipment, supplies and personnel. Under the terms of these agreements, assistance would only be provided when the lender determined that its own needs could be met while rendering assistance. Reimbursement is provided to the lender for the actual costs associated with providing assistance.

Two other potential aid arrangements had not been addressed. First, the District did not have negotiated standby agreements with vendors or contractors to provide emergency goods and services. Second, other than with the EBRPD, agreements had not





been established with local governments to mutually support response and recovery activities.

#### 4) Communications Systems

Primary and alternate District communications systems existed before the fire. The District Disaster Plan pre-assigned radio frequencies for disaster communications. All communications systems were tested at least monthly and whenever maintenance was performed on them. Planned upgrades to the backup communications system had not been fully implemented before the firestorm.

The District had direct telephone lines from its Operations Control Center to the UC Berkeley Seismographic Station, EBRPD, Oakland Police Department and Oakland Fire Department, but it was not an official or integral part of any local government emergency alert and warning systems or the Red Flag extreme fire conditions program sponsored by CDF. The District relied on telephone lines for interagency communications. Communications were enhanced with the EBRPD by a radio interface.

Several shortcomings were noted during this assessment. First, procedures for initiating communications during emergencies with city and county EOCs, PG&E, or Pacific Bell were absent. Second, procedures did not exist for gaining access to the Emergency Broadcast System or Emergency Digital Information System. Access to these systems facilitates the dissemination of emergency information and instructions.

#### 5) Damage Assessment and Impact Evaluation

The 1990 Disaster Plan includes procedures for itemizing water system damages; for identifying, removing and disposing of hazardous material spills; for priority inspection and restoration of critical water facilities; and for inspecting all facilities following an earthquake. However, procedures for obtaining general situation information, conducting damage assessments, or determining residual capabilities for other types of events had not been included in the plan. However, other District procedures had been established for converting damage surveys and information into properly documented damage cost estimates. The loss of information from portions of the OP/NET system suggests that redundant capabilities for transmitting information may be needed.

#### 6) Equipment and Supplies

The District Disaster Plan included an inventory of all available emergency supplies, equipment, vehicles and heavy equipment. A sufficient supply of fuel was available for District vehicles during the firestorm, and provisions had been made to transport essential supplies and key personnel during disasters. System design and engineering drawings and related data were maintained in an accessible location, but it does not appear that standard procedures were in place to ensure that these materials were kept current.





Emergency generators and portable pumps were available at the Lafayette Filter Plant and Danville Pumping Plant east of the Oakland-Berkeley Hills. None were located at the plants in the fire area. Consequently, time was used to move the equipment, and there were problems getting this equipment to the pumping plants in fire zone because of access controls at the Caldecott Tunnel and in the fire area. Section 3 of this report contains data about the number, capacities, locations, and operating times of this equipment.

All primary District vehicles were equipped with basic safety supplies, and additional supplies were stored in the Central Tool Room and in satellite shops in Walnut Creek, Upper San Leandro and the Lafayette Filter Plant.

## 7) Customer Relations and Public Information

The District has a designated Public Information Officer and procedures and mechanisms had been identified for advising customers and the public of emergency actions to be taken and of restoration schedules. Following the Loma Prieta Earthquake, the District had established a procedure for staffing additional customer service telephone lines in the Business Office to handle overflow calls.

## 8) Related Activities

In 1982, the EBRPD convened a Blue Ribbon Committee to study the fire danger in the Oakland-Berkeley hills. The Committee recommended that a Joint Powers Agency, composed of all local jurisdictions, including EBMUD, be formed to develop a comprehensive and fully-integrated fire plan. Specific recommendations were made for the District to manage its lands within the fire area for improved fire safety. The Committee report was widely distributed throughout District management and was formally presented to the Board. A JPA was never established because a majority of cities felt that it was unnecessary. However, District staff were directed by the Board to implement the specific recommendations for fuel break maintenance and vegetation control.

### **4.3.2 The District's Response to the Firestorm**

The response assessment, like the preparedness assessment criteria, guided the collection of documentary and interview data for this section of the report. Table 4-1 presents a chronology of key response events taken by the District. In sum, the principal subjects include the District's 1) alert and warning, 2) District notifications, 3) District EOC activation and deactivation, 4) communications, 5) situation assessment and reporting, 6) interagency coordination, 7) damage assessment and impact evaluation, 8) mutual aid requests, 9) employee welfare and information, 10) customer relations and public information, 11) after-action critique and report, and 12) recovery actions.





**Table 4-1**

**EBMUD RESPONSE CHRONOLOGY OF KEY EVENTS AND ACTIONS**

The following chronology lists by exact or the best approximate time known the major events related to the response to the fire by the District.

Sunday, October 20, 1991

- |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11:35 am   | OP/NET alarm sounds and personal observation of the fire made by Manager of Water Operations.                                                                                                                                                                                                                                                                                                                                                                                 |
| 11:36      | Partial activation of the District's EOC and on-call crews dispatched to fire area.                                                                                                                                                                                                                                                                                                                                                                                           |
| 12:00 noon | Additional crews began responding; continued until late afternoon.                                                                                                                                                                                                                                                                                                                                                                                                            |
| 12:45 pm   | Briefing on situation given to General Manager and some Board members.<br><br>Crews dispatched to move large portable generator from Danville to Claremont Center.                                                                                                                                                                                                                                                                                                            |
| 1:00       | PG&E contacts District about power restoration priorities.                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1:05       | Emergency Operations Team assignments made.                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 2:00       | Gwin Reservoir empty.                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2:00       | District personnel open a zone gate to increase water flow into the Broadway Terrace pressure zone upon request of firefighters.                                                                                                                                                                                                                                                                                                                                              |
| 2:30       | District EOC fully activated.                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 2:30       | Amito and Sherwick Reservoirs empty.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 3:00       | Emergency pumping started from Summit South pressure zone into Amito Pressure zone                                                                                                                                                                                                                                                                                                                                                                                            |
| 3:00       | Strathmoor Reservoir empty.<br><br>District representative on site at OFD Fire Command Center.<br>Designated liaisons dispatched to OFD's and BFD's Fire Command Centers.<br><br>District crews, after obtaining access from fire department personnel, begin closing service connections, assessing damages, and taking other actions in the fire area.<br><br>District Public Information Officer starts providing emergency instructions regarding water use to the media. |





Table 4-1 Continued

**EBMUD RESPONSE CHRONOLOGY OF KEY EVENTS AND ACTIONS**

|       |                                                                                                     |
|-------|-----------------------------------------------------------------------------------------------------|
| 3:20  | District liaison representatives report in to Fire Command Centers.                                 |
| 3:30  | Generator moved through Caldecott Tunnel.                                                           |
| 4:00  | Fire around the Claremont Center controlled; access available.                                      |
| 5:00  | Summit South, Swainland, and Hilltop Reservoirs empty.                                              |
| 5:00  | Summit East pumping plant started to provide 3,000 gpm to Summit pressure zone                      |
| 5:45  | PG&E power partially restored.                                                                      |
|       | Pumping resumes at Summit South, Berryman South, and Dingee Pumping Plants.                         |
| 6:00  | District EOC staff prepares response strategy for next 12 hours.                                    |
| 6:30  | District water and fuel trucks deployed to service fire apparatus; repeated at 1:30 am, October 21. |
| 7:00  | District crews cease closing service connections due to darkness.                                   |
| 7:20  | Marin Water District asked to provide portable pumps.                                               |
| 8:00  | Pinehaven #1 and #2 reservoirs empty.                                                               |
| 9:20  | Marin Water District pumps arrive at District.                                                      |
| 10:00 | Emergency pumping starts at Amito Pumping Plant.                                                    |
|       | District EOC staff placed on 12 hour shifts.                                                        |

Monday, October 21, 1991

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| 1:30 am    | District water and fuel trucks deployed for second time.                                     |
| 8:00       | District crews resume closing off service connections.                                       |
| 12:00 noon | Portable pump begins pumping 700 gpm from Amito pressure zone into Strathmoor pressure zone. |
| 3:00 pm    | District crews complete closing off of over 2,000 service connections.                       |





## Table 4-1 Continued

### EBMUD RESPONSE CHRONOLOGY OF KEY EVENTS AND ACTIONS

Tuesday, October 22, 1991

|                    |                                                                                             |
|--------------------|---------------------------------------------------------------------------------------------|
| 7:00 am            | Portable pump begins pumping 400 gpm from Strathmoor pressure zone into Gwin pressure zone. |
| 12:00 noon         | Restoration of water storage and operations (see Figure 4-1 and text below).                |
| [times<br>unknown] | Preliminary report made to District Board.                                                  |
|                    | Employee welfare and inquiry system set up.                                                 |
|                    | Customer hot line set up.                                                                   |
|                    | District staff on duty at fire victim relief center.                                        |
|                    | District EOC deactivated.                                                                   |

#### Restoration of Water Storage

As shown in Figure 4-1, water storage at or near normal pre-fire levels was achieved by 12:00 noon on October 22. By this time, operation of pumping plants with PG&E power where available and emergency generators, along with operation of additional portable emergency pumps had restored nearly-normal water storage to the fire area reservoirs. The locations where emergency generators and emergency pumps were located are shown in Figure 4-1.

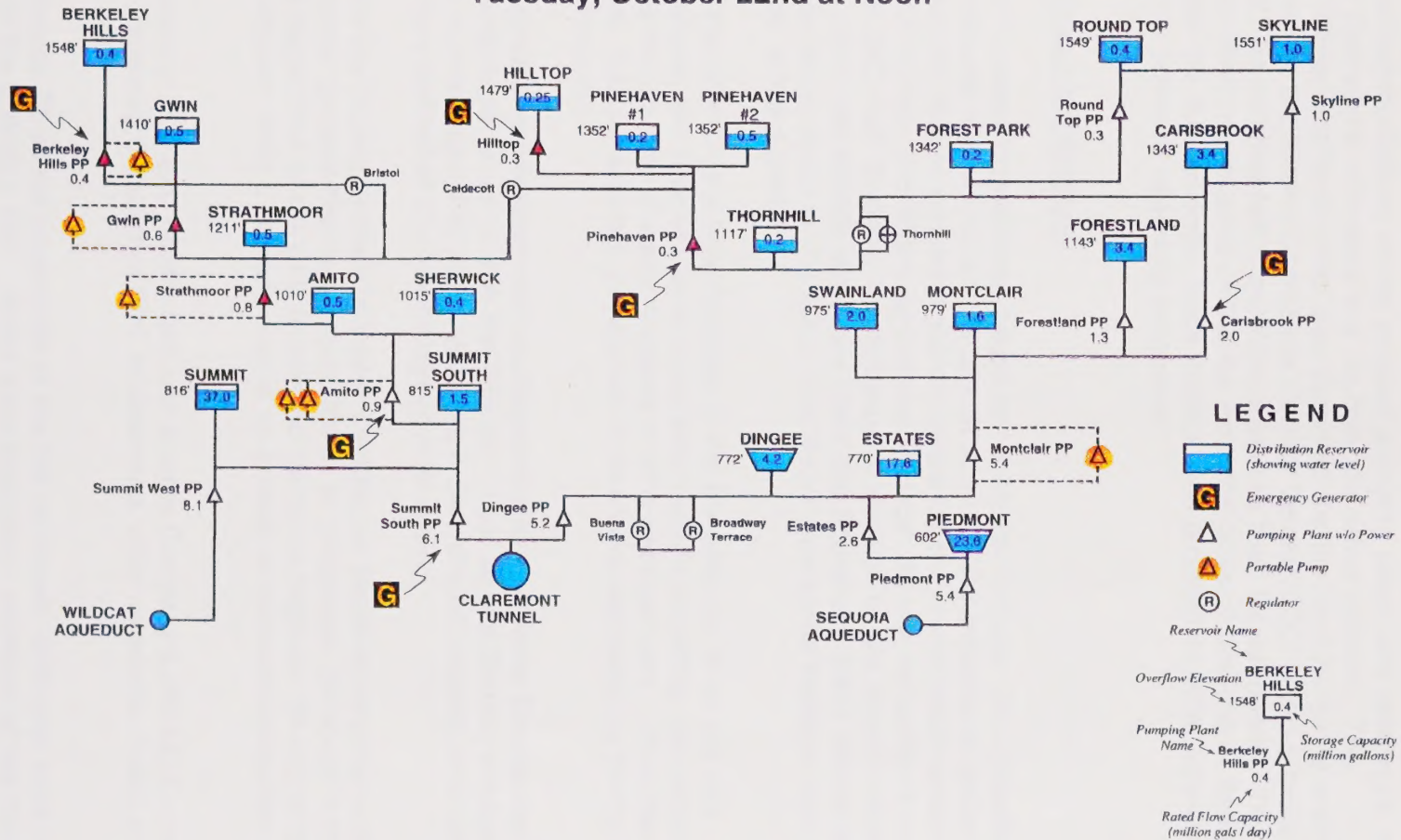




Figure 4-1

Restoration of Water Storage

1991 EAST BAY FIRE • EBMUD PRESSURE ZONES  
Water Storage Restored  
Tuesday, October 22nd at Noon







## 1) Alert and Warning

At approximately the same time that the District's OP/NET system began indicating power and communications failures at the involved pumping plants and reservoirs, the Manager of Water Operations witnessed the fire from his office window. The Superintendent of Water Distribution had also observed the fire from his home and had immediately reported to the District Operations Control Center (OCC) without being called. In route to the OCC, he commenced to mobilize resources from his car phone. The District never received any official notification of the fire from the cities of Oakland or Berkeley or from their respective fire departments. Such notifications provided to other agencies like EBMUD is a common standard operating procedure.

## 2) District Notifications

The District's internal notifications began at 11:35 am, October 20 - immediately following the first internal alarms. Given the lack of any official notifications about the scope of the fire and the lack of a specific known cause for the power failure which affected the OP/NET system, the Water Operations Manager did not immediately activate the District's entire EOC staff (Disaster Committee). In addition to the Superintendent of Water Distribution, who was already there, the Plant and Equipment (P&E) Maintenance Manager was requested to report to the EOC. The Water Operations Manager also advised the General Manager of the situation.

Because of the loss of data from facilities in the fire area due to power and communications failures, the District had to make assumptions regarding the status of pumping plants and the amount of water available in affected reservoirs. When the status of the fire permitted, field crews were dispatched to reservoirs and pumping plants to provide status information.

The P&E Maintenance Manager and the Superintendent of Water Distribution notified crews by telephone to report into the District. Also, several District employees (management and non-management) called in asking if they should respond, and others reported in when they learned of the fire on television or radio.

At 11:35 am the Superintendent of Water Distribution began attempting without success to contact the Oakland Fire Department (OFD) by telephone. By about 3:00 pm District staff were dispatched to the OFD Command Center at Highway 24 and to the Berkeley Fire Department (BFD) Command Center to provide a communications link with the District.

At approximately 1:00 pm, Pacific Gas and Electric Company's (PG&E) Central Division Manager contacted the District EOC to determine what its priority needs were for power restoration.

Later on October 20 as the magnitude of the fire increased, additional staff were notified to report to the District's EOC. Some were designated members of the Disaster Committee, and others were requested because of special skills. Examples include





developing computer-generated maps of the involved system, establishing system status boards, staffing District radios, and answering customers telephone calls. Additional field crews were also requested to open zone gates, to shut-off flowing services, and to deploy emergency generators and pumps.

District rangers also responded to assist EBRPD on the Grizzly Peak Boulevard fire line. They worked extended shifts fighting the fire and drove water tankers into the fire area. Coordination with EBRPD was effective largely because of the wildland fire protection planning that had been done earlier.

### 3) District EOC Activation and Deactivation

By late morning on October 20 the District EOC was partially activated by the Water Operations Manager, and it was fully activated by approximately 2:30 pm. The General Manager and at least two Board members were also present in the EOC for a period of time in the later afternoon. By 10:00 pm the EOC staff was placed on 12-hour shifts for the duration of the incident. The District EOC remained partially activated until October 22.

Some common specific EOC functions were not implemented, but they were not part of the District's existing Disaster Plan. Some EOC staff believed it was difficult to tell who was in charge. Without specific assignments, EOC staff performed roles they thought were needed. As a result, there was initial confusion and duplication of efforts. However, field personnel who were interviewed believed that the EOC staff was functioning well and was effective in obtaining the necessary resources.

There was no designated District liaison with external agencies, and it was difficult to determine what external notifications and status reports had been made and when. In addition, during the first five to six hours of activation no briefings were conducted in the EOC to compile a collective overview of the situation and to establish response priorities. However, by approximately 6:00-7:00 pm the EOC staff did develop an overall response strategy for the next 12 hours. Part of that strategy was to position equipment and personnel south of the burn area in anticipation of spread of the fire toward that direction.

Some of the functions and activities which would normally be performed by the operations staff spilled over into the EOC. Consequently, the EOC became primarily operations-focused, and the size and configuration of the facility was inadequate for the number and type of operations and support staff working there. Furthermore, since access to the EOC facility was not strictly limited to essential personnel, EOC staff were frequently interrupted to provide information and to answer questions from visitors and the media.

Some staff members noted that there were too few copies (three or four) of the District Disaster Plan in the EOC. In the absence of a standard EOC activities log, staff wrote notes on random pieces of paper; often these were not dated, timed or signed. In cases where time was indicated, there was no notation of am or pm, which makes it difficult to determine the exact chronology of events. Military time is usually used for





emergency operations and should be adopted by the EOC staff.

#### 4) Communications

With the exception of the OP/NET system discussed above, the District's telephone and radio systems performed without incident. However, a significant amount of District radio traffic was not recorded because the equipment was out of service as the tape for the previous 24 hours was being replaced when the fire started. The OP/NET system lost power in the fire area, and data about the water system was not transmitted to the District's Operations Control Center.

Field crews did not experience radio dead spots, and all crews were provided with District portable and/or mobile radios, and/or cellular telephones. Not all District vehicles used during this incident had mobile radios. In some cases portable radios required additional charged batteries which were not immediately available in the field.

As mentioned previously, specific EOC functions were not assigned, so initially communications were not centralized. However, as the incident progressed, most field crews reported via District radio to the P&E Maintenance Manager in the EOC. District staff at the Oakland communicated with the Construction Manager in the EOC via District cellular phones.

Also as noted, the District did not have radio communication with Oakland or Berkeley Fire Departments or EOC's. For the first few hours, therefore, the District EOC staff could not make telephone contact with the Oakland Fire Command Center. By 3:00 pm District staff were dispatched to the Oakland Fire Command Center to establish cellular telephone link with the District's EOC. Throughout the incident the District did have reliable radio communication with the EBRPD Dispatch Center and telephone contact with the Berkeley Fire Department.

There were insufficient internal and external telephone lines and telephone directories. Two District telephone lines in Water Operations on the second floor of the District Administration Building were designated for use by the District's Public Information Officer. Many calls from the media came directly into the EOC. Additional District telephone lines were staffed in the Business Office to handle the overflow of customer inquiries to District telephone operators.

There was difficulty receiving television reception in the administration building due to the lack of a rooftop antenna.

#### 5) Situation Assessment and Reporting

Beginning at 11:35 am, following a telephone call from the Water Operations Manager to the P&E Maintenance Manager, the P&E Manager directed that on-call crews be notified. They were later dispatched to trouble areas, and most arrived by 12:00-1:00 pm. Additional crews responded from 1:00 to 4:30 pm. Again, intelligence gathering was





hampered by loss of the OP/NET system and because field crews could not be dispatched to manually check all involved pumps and reservoirs until access to the fire areas was obtained from fire department personnel. Other personnel called in or responded voluntarily.

Nonetheless, regular status reports were provided to the District EOC from its facilities' staffs and field crews as access to the burned areas was gained. However, individual EOC staff autonomously reacted to the reports and requests which they received, and there was minimal information sharing between EOC members. A comprehensive internal information exchange system and District status report was not compiled until Sunday evening.

The District's Board of Directors was advised of the situation by the General Manager during the afternoon of October 20. Some of the EOC staff interviewed noted that the method for keeping senior management informed of the situation was awkward and could have been better organized and less disruptive.

The District EOC did not regularly communicate status information with the Oakland and Berkeley City EOC's, nor was it asked to. However, several informal telephone status reports were made to the Oakland EOC by the P&E Maintenance Manager and the Construction Manager. For the most part, regular external status reporting was accomplished through the District's designated liaisons at the Oakland (and later joint Oakland/CDF) and EBRPD Fire Command Posts on Highway 24. In fact, the EBRPD never had to request water status information because the District's representative regularly reported it to EBRPD personnel.

Standard status reporting formats were not utilized and, with the exception of the P&E Maintenance Manager, EOC logs were not compiled. However, telephone and radio operator logs were maintained.

#### 6) Interagency Coordination

Interagency planning and response coordination within the District's service area is cumbersome. Since the County of Alameda was not a designated Disaster Operational Area charged with responsibility for coordinating the efforts of all municipalities and special districts within its boundaries, the District had to coordinate its response separately with Oakland, Berkeley and EBRPD.

Coordination was made more difficult because Oakland's EOC was separate from the Fire Incident Command Post, because neither Oakland nor Berkeley had an established protocol or mechanism for communicating directly with EBMUD during disasters, and because EBMUD did not have access to interagency radio frequencies (OFD, BFD or Fire White).

OFD and CDF utilized the Incident Command System (ICS) to direct and coordinate field operations during this incident. Since EBMUD staff had not received ICS training, it was difficult for field crews to determine who they should report to at the Fire Incident





Command Post.

On the other hand, coordination with EBRPD posed no problem. Since the District's Watershed staff regularly interface, train and drill with EBRPD staff, communications and response procedures were pre-established. EBRPD personnel stated that EBMUD's response to the fire was good. District rangers assisted Park personnel on the fire lines, and the Watershed Manager provided the EBRPD Fire Chief with regular status reports.

As noted earlier, the District did not have an EOC staff member designated as liaison with external agencies, including the cities, county, state, PG&E and Pacific Bell. During the post-fire recovery period, the District worked with the City of Oakland to provide information and services to the fire victims in a Relief Center.

#### 7) Damage Assessment and Impact Evaluation

Ongoing inspections of District facilities were conducted throughout the impacted area as these areas became accessible. Emergency repairs and restoration commenced at 3:00 pm on October 20, and by 12:00 pm on October 22 all pumping plants were either operational or emergency equipment was in place, and more water than normally stored for fire suppression had been restored to all reservoirs. Damage assessment teams comprised of District superintendents and engineers inspected each facility and photographed all damages once the fire was extinguished in each area. In addition, each department reported damage cost estimates to the Accounting Department.

Damage reports were reviewed by Engineering and Operations Team Leaders before being forwarded to the General Manager and the Executive Committee. A preliminary report was made to the District Board on October 22.

#### 8) Mutual Aid Requests

Despite the magnitude of this event, a relatively small number of requests was made for assistance to and from the District. The Oakland and Berkeley Fire Departments were advised by the District's on-scene liaison representatives that EBMUD was available to provide assistance as needed.

The District provided its entire stock of 2 1/2 and 3 inch hydrant adapters to Oakland and Berkeley Fire Departments. On October 20 and 21 District water and fuel trucks were deployed into the fire area to supply Oakland and mutual aid fire vehicles and to refuel portable light sets. District rangers were dispatched to assist EBRPD with backburning and holding the fire line at Grizzly Peak Boulevard.

Contra Costa Water District, Santa Cruz Water District and the Marin Municipal Water District contacted EBMUD to offer assistance. At 7:20 pm October 20 Marin Municipal Water was asked to provide two portable pumps which arrived at EBMUD at 9:20 pm.





## 9) Employee Welfare and Information

Most field crews were deployed with standard safety gear (hard hat, boots, and first aid kits), but with the exception of District rangers, only a few crews had dust masks available. None had fire-retardant protective clothing or self-contained breathing apparatus (SCBA) in their District vehicles. This was not surprising since response to this type of situation is not routine for District staff. The OFD did offer to provide protective clothing and SCBA's to District staff who were going into the fire area to refuel vehicles.

Despite the lack of fire retardant clothing, and the fact that the District had at least 150 crew members out in the fire areas performing various functions while the fire continued to burn, only one employee was injured when he stepped into a hole and hurt his back.

District rangers were properly equipped with fire protective clothing and equipment and worked the fire lines for 15-16 hours. Other District field crews were limited to 12-hour shifts. All on-duty employees in the EOC and in the field were provided with food and beverage at least once every eight hours.

A system for handling employee/family welfare inquiries was established on October 22. Despite the fact that a number of on-duty employees lived within the fire area, situation reports were not generally disseminated to all employees, and no system had been pre-identified for doing so. The District did provide employees (and immediate family members) who lost their homes with special leave. However, formal Critical Incident Stress Debriefing (CISD) was not provided for EOC staff, field crews, or for employees who lost their homes.

## 10) Customer Relations/Public Information

At 3:00 pm on October 20, the District's Public Information Officer began to provide customers with instructions via television and radio. They included requests to reduce water usage to preserve water for firefighting. On October 22 the District established a customer hotline and staffed an information table at the Oakland Fire Victim Relief Center.

As soon as the immediate emergency response phase was terminated, several operations staff were designated to help respond to media inquiries. These individuals were briefed on how to provide effective media interviews by a District consultant.

## 11) After-Action Critique and Report

The District did not conduct a formal critique of its response immediately following the firestorm, and it was not asked to participate in OFD or BFD critiques. Key staff were requested to complete a written record of their observations and actions; written reports were presented to the Board on October 22, 1991 and on March 24 and April 28, 1992.





## 12) Recovery Actions

District crews were advised of alternate work assignments by work supervisors. In addition, on October 21 general employee instructions were prepared for dissemination by District telephone operators.

The District waived reconnection charges for those who would rebuild and deducted from bills the cost of water used by customers to protect their homes. As a matter of District policy, there was no charge for water used by firefighters.

Following completion of a comprehensive survey of all District facilities, insurance claims and state and federal disaster assistance applications were prepared by District staff.

District crews handled all system repairs and debris clearance. Consideration is currently being given to contracting for removal of damaged trees in the burn area and for replacement of the fire-damaged Amito reservoir.

Following the fire, the Executive Committee appointed the Construction Manager to serve as an interim Emergency Response Assessment Manager to coordinate the District's fire reporting and recovery efforts. In addition to the Emergency Response Assessment Manager, various District staff have participated on community task forces and committees established to provide recommendations for improvements to emergency response systems and capabilities.

### **4.4 Recommendations**

Although the District responded effectively to the firestorm emergency, when its degree of preparedness is compared to optimum criteria significant improvements could be made. This is one of the foci of Phase II of this project. The recommendations which follow cover only those issues raised during this Phase I evaluation.

1. The Board should establish District-wide policies for the development and implementation of a comprehensive District-wide emergency management program, including the preparation, maintenance and testing of emergency operations plans by all divisions and departments.

2. The Board should adopt an Emergency Powers Resolution that contains specific provisions, including criteria and authority for declaring a District Emergency, the emergency powers of the General Manager and the Emergency Operations Director, and designates successors to the General Manager.

3. The District's Emergency Operations Plan should be upgraded to emphasize comprehensive emergency management as well as operations-based response capability. The Plan should address the broad emergency management issues of an overall concept of operations, direction and control, external agency liaison, resource management, and public information. The plan should include criteria and provisions for declaring a District emergency and should clearly articulate emergency roles, responsibilities, and authorities





during declared disasters. The plan should be broadened to include all likely disasters which could have a major impact on the District and its customers. Also, the Plan should include a procedure and mechanism for offering assistance to local governments during emergencies. To support the planning process, the current Disaster Committee should be redesignated as the Emergency Operations Team and staff support should be provided by the new District Emergency Preparedness Officer.

4. The Emergency Operations Plan should include a procedure for initiating communications with city and county EOC's, PG&E and Pacific Bell during disasters. The plan should include an incident-level District liaison to public safety agencies. It also needs a procedure for accessing local Emergency Broadcast Stations or the Emergency Digital Information System to disseminate emergency information and instructions.

5. A detailed procedure and monitoring system should be established to formalize procedures used by the District for intelligence gathering or capability analysis. A formal procedure also is needed to convert damage data and field assessment surveys into cost estimates for repair and claims management activities.

6. The emergency management organization should be restructured along the lines of the Incident Command System (ICS) which is very widely used for emergency management. Specific roles and responsibilities should be established for all EOC staff, and the role of the Board during emergencies should be clearly defined. (This is currently in process.)

7. Criteria should be established for partial and complete activation and deactivation of the District EOC, including specific internal and external notification procedures. Also, the EOC facility should be reconfigured and upgraded to allow for separate Operations and Policy Groups. (This is currently in process.) A standard log or other record keeping system should be designed for use by the EOC staff.

8. The District should negotiate standby agreements with critical vendors or contractors for the supply of their services and products in disaster situations. Related procedures need to be established with local governments, other than EBRPD, to expedite response and recovery activities.

9. An emergency communications network, including alert, warning and reporting procedures and links to the Red Flag Program, Emergency Broadcast and Emergency Digital Information Systems, should be established with local emergency response agencies. This should be a high priority item for the new Emergency Preparedness Officer.

10. All District utility vehicles have radios; however, some car pool vehicles do not. In the future, radio-equipped vehicles should be used whenever possible when responding to emergencies. District participation in the Red Flag program will require the preparation of internal policies and procedures governing the District's response if it is placed on alert.

11. The District's current employees who are Radio Amateur Civil Emergency Services (RACES) operators should be integrated into the emergency communications





network. A permanent RACES base station should be installed in or near the EOC.

12. System design and engineering drawings and data were maintained in an accessible location behind the OP/NET screen. It is unclear, however, if a procedure was in place and enforced for ensuring that these materials were current. These procedures need to be reviewed, and current materials should replace obsolete ones on a regular basis. Their location should be stated in the EOP and should be known to key EOC staff members.

13. Consideration should also be given to establishing multidisciplinary field emergency response teams at the existing Area Control Centers. These crews should be provided with essential safety gear, redundant communications capabilities, and standard emergency supplies and equipment.

14. A policy and procedure for debriefing employees, conducting critiques and compiling an after-action report following all emergency events should be established. Consideration also should be given to pre-identifying a team to provide employee debriefing and counseling immediately following major emergencies.

15. The Op/NET system should be upgraded so that remote transmitters have supplemental emergency power.

16. Also, emergency supplies and equipment (e.g., portable generators and pumps) should be stored more widely throughout the service area. (This is currently in process.)

17. Regardless of the outcome of Alameda County's efforts to be designated an Operational Area by state OES, the District will still to coordinate its planning, training, and exercise activities with multiple jurisdictions throughout its service area. The new Emergency Preparedness Officer position should facilitate this continuing process.

18. The District should continue to work closely with all municipalities and others involved in developing fire safe land use policies, building codes, and related preventive measures.

19. Phase II will examine various alternative mitigation measures which will result in recommendations about improving the water system. This is especially important in the context of the lessons learned from the firestorm and that are expected from the seismic vulnerability analysis. Mitigation strategies should include examining the subject of installing redundant electrical power or providing portable pumps at potentially vulnerable pumping plants.





## **APPENDIX**

### **SELECTED REFERENCES AND DOCUMENTS REVIEWED**

Alameda County Sheriff's Department, **The 1991 East Bay Hills Firestorm After Action Report**, February 1992.

American Water Works Association, **Emergency Planning for Water Utility Management**, 1973.

California Department of Water Resources, **Emergency Handbook for Water Supply Managers**, undated.

California Office of Emergency Services, **California Utilities Emergency Plan**, June 21, 1990.

California Office of Emergency Services, **Quality Assessment Survey**, Utility Policy Committee, 1991.

California Office of Emergency Services, **Situation Summary, Oakland Area Fire Storm**, as of 1300 hours, October 21, 1991.

California Office of Emergency Services, **The East Bay Hills Fire - A Multi-Agency Review of the October 1991 Fire in the Oakland/Berkeley Hills**, East Bay Hills Fire Operations Review Group, February 27, 1992.

California Seismic Safety Commission, **Meeting Minutes of December 12, 1991**.

City of Oakland, **A Report From the City Manager's Office Regarding the City of Oakland's Clean-Up, Erosion Control, and Rebuilding Plans for the Fire-Damaged Oakland Hills Area**, October 29, 1991.

City of Oakland Fire Department, **The Oakland Tunnel Fire, October 20, 1991**, February 1992.

County of Nevada, Department of General Services, **Oakland Hills Fire - City Manager's Report on Cleanup and Rebuilding Plans**, Memorandum of February 12, 1992 by Dennis W. Babson.

Department of Defense, Office of Civil Defense, **Civil Defense Aspects of Waterworks Operations**, June 1966.

East Bay Municipal Utility District, **Maintenance Shift Supervisor's Emergency Response Plan for Seismic Incidents**, May 1990.





East Bay Municipal Utility District, **Emergency Operations Plan**, October 1990. East Bay Municipal Utility District, Wastewater Department **Earthquake Operations Plan**, August 1990.

East Bay Municipal Utility District, **Oakland-Berkeley Hills Fire Status Report from Manager of Water Operations to the Board of Directors**, October 22, 1991.

East Bay Municipal Utility District, **Special District No. 1 Contingency Plan**, Revised, November 1991.

East Bay Municipal Utility District, **Description of District's OP/NET System**, Attachment 12 to February 1992 Request for Qualifications (RFQ).

East Bay Municipal Utility District, **Emergency/Disaster Plan**, Revised, Purchasing Division, February 1992.

East Bay Municipal Utility District, **Preliminary Report on EBMUD's Response to the East Bay Hills Firestorm**, Report to the Board of Directors, March 24, 1992.

East Bay Municipal Utility District, **EBMUD Reports**, April 1992.

East Bay Municipal Utility District, **East Bay Hills Firestorm Update**, Staff Report to the Board of Directors, April 28, 1992.

East Bay Municipal Utility District, **Waterline**, First Edition, 1992.

East Bay Regional Park District, **1982 Report of the Blue Ribbon Urban Interface Fire Prevention Committee**, February 1982.

East Bay Regional Parks District, **Summary of the Fire History in the East Bay Hills From 1923 to 1991**, undated.

Federal Emergency Management Agency, **Hazard Mitigation Report for the East Bay Fire in the Oakland-Berkeley Hills**, FEMA 919-DR-CA.

Los Angeles County Fire Department, **Unofficial Fire Critique**, Battalion Chief G.D. Johnson, December 12, 1991.

Metropolitan Water District of Southern California, **Emergency Response Plan**, January 1992.

Pacific Gas and Electric Company, **Firestorm: Oakland-Berkeley Hills**, Central Division, undated.

Swiss Reinsurance Company, **Fire of the Future**, undated.

Task Force on Emergency Preparedness and Community Restoration, **Final Report**, February 3, 1992.

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